IT-Supported Collaborative Creativity

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Preface

Creativity and collaboration are two essential aspects in our daily lives. Creative people is what drives our society and without creativity, novel and innovative approaches would be missing. With collaboration, creativity is reaching it's full potential unleashing synergetic effects. As a person who considers himself as creative, the phenomena of creativity has always been my interest. Having the possibility to conduct six years of research on this topic, intrinsically motivated me and deeply satisfied me of the results I produced. Creativity is my mindset. Being a digital native, having grown up with computers and being given the freedom to evolve and experiment with computers, furthermore motivated me to study Wirtschaftsinformatik and conduct my promotion in this field. Even if the relationship between Information Technology and creativity does not immediately seem plausible, it is still present and represents an interesting object of investigation. Creativity can highly benefit from Information Technology. Combining my passion for Information Technology with my creative mindset, additionally motivated me to conduct this research. From the first day at the Chair of Informationsmanagement (wi2), I was working closely with my colleagues together, benefiting from their expertise and contributing my humble knowledge at this point. Collaboration immediately became my number one way of working and continued throughout the time of my doctorate, which can also be seen in the average number of authors ($M = 3,6$) of my publications.

This dissertation would have not been possible without creativity and especially not without collaboration. I want to thank my colleagues, who stood by my side the last six years. Alexander, who introduced me to the world of writing papers for publication. Jens, for his steady reflective views and comments on my topic of research and approach. Linda for her support during my first years as a doctorate and our detours on Gamification. Patrick for his help on my first conference visit and his support with creating figures. Timo, Michael M., Michael K., Paul and Felix for the endless hours of creative and analytical thinking, technical help, productive hours in the gym and their overall support and collaboration. Rangina for her creative thoughts, inspiring digressions and her language skills. Christoph and Beke for their collaboration and support on research projects, papers and my great Design Thinking education. And Christoph as well for being my second superviser.

Michaela, for her endless support, positive energy, warm heart and love.

Lastly, I would like to express my special appreciation and thanks to Susanne, for giving me the possibility to conduct my research under her supervision. I thank her for her open mind, the freedom in conducting my research, for encouraging me, her inspiring comments and creative thoughts. Her approaches and especially her mindset on collaboration that shaped and fostered my way of thinking.

Thanks to everyone for the beneficial collaboration and creative inspiration along my way.

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Acronyms

AR Action Research

ADR Action Design Research

AD Anchored Discussion

API Application Programming Interface

AI Artificial Intelligence

CoSS Collaboration Support Systems

CEM Collective Effort Model

CPS Complex Problem Solving

CI Confidence Interval

CSS Creativity Support System

CST Creativity Support Tool

DT Design Thinking

DSR Design Science Research

DSRM Design Science Research Methodology

EBS Electronic Brainstorming

GCSS Group Creativity Support System

GSS Group Support System

IT Information Technology

IS Information Systems

ICSS Individual Creativity Support System

MNT Media Naturalness Theory

MRT Media Richness Theory

MST Media Synchronicity Theory

NLP Natural Language Processing

REST Representational State Transfer

SIAM Search for Ideas in Associative Memory

SMM Shared Mental Model

TCM Team Creativity Model

TEI Team Emotional Intelligence

TMM Team Mental Models

Zusammenfassung

Unternehmen und Organisationen müssen sich ständig weiterentwickeln, um am Markt beständig zu sein und geschäftsfähig zu bleiben. Eine wichtige Rolle sind Innovationen, die diesen kontinuierlichen Unternehmenserfolg sicherstellen. Innovationen zu produzieren hängt stark von Kreativität ab, weshalb eine aktive Unterstützung sinnvoll und lohnenswert ist. Kreativität kann dabei durch Informationstechnik unterstützt werden und entfaltet vor allem in Teams und Gruppen ihre größte Wirkung. Kollaboration und die Betrachtung unterschiedlicher Kollaborationsmechanismen spielt in diesem Kontext gleichermaßen eine wichtige Rolle, wie die aktive Unterstützung durch Informatikstechnik. Die vorliegende Dissertation beschäftigt sich mit der Fragestellung, wie Informationssysteme gestaltet werden können, um einerseits Informationstechnik so einzusetzen, dass sie aktiv Kreativität unterstützt, andererseits so gestaltet werden sollte, dass kollaborative Kreativitätsprozesse gefördert werden. Mit Hilfe einer systematischen Literaturanalyse wurden dabei aktuelle Kreativitätsunterstützungsysteme untersucht und die Notwendigkeit der Forschung dargelegt. Mit einem gestaltungsorientierten Vorgehen wurden daraufhin unterschiedliche Ansätze entwickelt und evaluiert, die die Fragestellung adressieren. Dabei sind insgesamt 25 wissenschaftliche Artikel entstanden, von welchen fünf in diese Dissertation eingebunden sind. Unterschiedliche durchgeführte Studien zeigen daraufhin den Mehrwert von aktiver Unterstützung durch Informationstechnik auf und geben Gestaltungsrichtlinien zur besseren Unterstützung von kollaborativer Kreativität.

1 Introduction

"The desire to do something because you find it deeply satisfying and personally challenging inspires the highest levels of creativity, whether it's in the arts, sciences, or business."
- Teresa Amabile

Teresa Amabile, Professor of business administration in the Entrepreneurial Management Unit at Harvard Business School, already recognized the importance of creativity for business activities in the late 1970s. By contributing to the knowledge on how organizations can benefit from the support of creativity, her research highly influenced the field of creativity. The research of creativity, that primarily started in the field of psychology and philosophy with researchers such as James Melvin Rhodes, Mihaly Csikszentmihalyi, Joy Paul Guilford and Ellis Paul Torrance then migrated to other research fields such as management, economics, education and technology. Especially the research on organizational creativity influenced the way companies perceive their employees and benefit from their ability to come up with novel ideas. With the awareness of the importance of creativity and the systematic support of creativity, organizations benefited from new ideas that transformed into innovations and valuable business models (Amabile, 1988). Over the course of time, various creativity support techniques were developed (VanGundy, 2008) and presented to further enhance the creative potential. With the rise of Information Technology (IT), computers and software systems are used to additionally shape the way creativity can be supported (Massetti, 1996; Couger et al., 1993). This broadened the research of creativity, and studies dealing with the possibilities and effects of IT in the context of creativity were published. IT has become an important aspect when supporting individuals and groups during the creativity process, resulting in various digital artifacts and specific support systems (Olszak and Kisielnicki, 2016). Such Information Systems (IS) consist of individuals or groups and IT that generate and/or use information and that are linked by communication relationships to perform tasks of a creative nature (Massetti, 1996). However, the possibilities that IT nowadays offers are not yet fully exhausted, and the way computer systems can enhance creativity are yet to be examined and developed. These new possibilities lead to a profound research gap. So far, research and application in this area has been limited mainly to IT supporting the organization and management of ideas without taking full advantage of IT as an active contributor to creativity-intensive processes. And despite extensive research into group creativity, information systems have not been designed to effectively promote collaborative processes.

This research gap challenged the author to pursue his research on IT-supported collaborative creativity and additionally inspired the author to conduct personally challenging research and to close the research gap on IT-supported collaborative creativity. This dissertation presents the different research approaches on how to benefit of the use of IT as an active contributor to support creativity (objective 1) and on how IS can be designed to support collaborative creativity (objective 2). In doing so, five independent research publications are included in this dissertation enclosed by a framework comprising of the theoretical background, the research gap and the overall implications and conclusion.

1.1 Publications

In this section, an overview of the author's research publications is given. Five publications are directly included in this dissertation and are listed with additional information. Overall the author published 25 peer-reviewed articles, that relate to the topic of IT-supported collaborative creativity. A detailed contextual framework for all publications is given in chapter 5.

1.1.1 Publications of the Dissertation

In this section the five directly included publications are listed, followed by a list of all publications sorted by the year of publication.

Paper 1. *Tracking Down the Negative Group Creativity Effects with the Help of an Artificial Intelligence-Like Support System (2015)*
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Contribution: A novel artifact and the results of an experiment on how to overcome negative group creativity effects.
Dominik Siemon, Linda Eckardt, Susanne Robra-Bissantz

Paper 2. *A Creativity Support Tool for Cognitive Idea Stimulation in Entrepreneurial Activities (2018)*
In International Journal of Entrepreneurship and Small Business
Contribution: A novel artifact and the results of an experiment on how to support entrepreneurs with semi-automated questions generated by a creativity support system.
Dominik Siemon, Susanne Robra-Bissantz

Paper 3. *Anchored Discussion: Development of a Tool for Creativity in Online Collaboration (2016)*
In Journal of Universal Computer Science

Contribution: The non-distinctive results of an experiment on how to increase a shared mental model with the use of anchored discussion.
Georg Link, Dominik Siemon, Gert-Jan de Vreede, Susanne Robra-Bissantz

Paper 4. ***Forming Virtual Teams - Visualization with Digital Whiteboards to Increase Shared Understanding, Satisfaction and Perceived Effectiveness (2017)***
In Proceedings of the International Conference on Information Systems (ICIS)
Contribution: The results of an experiment on how to increase shared understanding, satisfaction and perceived effectiveness with the use of a digital whiteboard.
Dominik Siemon, Beke Redlich, Christoph Lattemann, Susanne Robra-Bissantz

Paper 5. ***One for all and all for one - towards a framework for collaboration support systems (2017)***
In Education and Information Technologies
Contribution: Design guidelines for collaboration support systems that follow and complay the principles of collaboration.
Dominik Siemon, Felix Becker, Linda Eckardt, Susanne Robra-Bissantz

1.1.2 Full List of Relevant Publications

In this section the author's publications relevant to the dissertation are chronologically listed, excluding the five previously mentioned publications.

2018

Paper 6. ***Nutzerzentrierte Dienstleistungsinnovation durch digitales Design Thinking - Herausforderung und Potenziale für Wissenschaft und Praxis***
In Service Business Development
Beke Redlich, Felix Becker, Dominik Siemon, Susanne Robra-Bissantz, Christoph Lattemann

Paper 7. ***Virtual Moderation Assistance - Creating Design Guidelines for Virtual Assistants Supporting Creative Workshops***
In Proceedings of the 22nd Pacific Asia Conference on Information Systems (PACIS)
Timo Strohmann, Simon Fischer, Dominik Siemon, Florian Brachten, Susanne Robra-Bissantz, Stefan Stieglitz, Christoph Lattemann

Paper 8. ***"Meet to Succeed" - A Serious Game to Support Team Emotional Intelligence***

In Proceedings of International Conference On Design Science Research In Information Systems And Technology (DESRIST)
Dominik Siemon, Jon-Conrad Linzmeier, Susanne Robra-Bissantz

Paper 9. ***Creativity Tests Versus Cognitive Computing: How Automated Personality Mining Tools Can Enhance Team Composition***
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Rangina Ahmad, Dominik Siemon, Susanne Robra-Bissantz

Paper 10. ***Collaborative Service Blueprinting for Design Thinking: Evaluation of a Digital Prototype***
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Tobias Potthoff, Dominik Siemon, Konstantin Wilms, Sascha Möser, Marco Hellmann, Stefan Stieglitz, Susanne Robra-Bissantz

Paper 11. ***Towards Semi-Virtual Design Thinking - Creativity in Dispersed Multicultural and Multidisciplinary Innovation Project Teams***
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Beke Redlich, David Dorawa, Dominik Siemon, Christoph Lattemann

2017

Paper 12. ***The Benefits of Creativity Support Systems for Entrepreneurs: An Exploratory Study***
In Proceedings of the Americas Conference on Information Systems (AMCIS)
Dominik Siemon, Sorour Khalili Narani, Susanne Robra-Bissantz

Paper 13. ***brAInstorm: Intelligent Assistance in Group Idea Generation***
In Proceedings of the International Conference On Design Science Research in Information Systems And Technology (DESRIST)
Timo Strohmann, Dominik Siemon, Susanne Robra-Bissantz

Paper 14. ***Digitization of the Design Thinking Process - Solving Problems with Geographically Dispersed Teams***
In Proceedings of the International Conference on Human-Computer Interaction (HCI.International)
Christoph Lattemann, Dominik Siemon, David Dorawa, Beke Redlich

Paper 15. ***Shared Mental Models in Creative Virtual Teamwork***
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Beke Redlich, Dominik Siemon, Christoph Lattemann, Susanne Robra-Bissantz

2016

Paper 16. ***Design Guidelines for Context-Aware Creativity Support Systems***
In Journal of Creativity and Business Innovation
Dominik Siemon, Susanne Robra-Bissantz

Paper 17. ***Creativity and Entrepreneurship - The Role of Creativity Support Systems for Start-Ups***
In Proceedings of the Mediterranean Conference on Information Systems (MCIS)
Dominik Siemon, Sorour Khalili Narani, Kristin Ostermeier, Susanne Robra-Bissantz

Paper 18. ***From Group Creativity to Collaborative Creativity - A Framework for Collaborative Creativity Support Systems***
In Proceedings of the Think Cross Change Media Conference (TCCM)
Dominik Siemon, Susanne Robra-Bissantz

Paper 19. ***Cooperation isn't just about doing the same thing - Using Personality for a Cooperation-Recommender-System in Online Social Networks***
In Proceedings of the International Conference on Collaboration and Technology (CRIWG)
Jens Lamprecht, Dominik Siemon, Susanne Robra-Bissantz

Paper 20. ***"Tinkering for Creativity": An Experiment to Utilize MaKey MaKey Invention Kit as Group Priming to Enhance Collaborative Creativity***
In Proceedings of the Americas Conference on Information Systems (AMCIS)
Dominik Siemon, René M. Plaumann, Arne Regenberg, Yuan Yuan, Zheng Liu, Susanne Robra-Bissantz

Paper 21. ***Semi-Automated Questions as a Cognitive Stimulus in Idea Generation***
In Proceedings of the Hawaii International Conference on System Sciences (HICSS)
Dominik Siemon, Taras Rarog, Susanne Robra-Bissantz

2015

Paper 22. ***Kreativität und Entrepreneurship - Die Rolle von Kreativitätsunterstützung in der Existenzgründung***
In Petrov, E.; Batchvarov: 25 Jahre FDIBA - German Engineering: Made in Bulgaria Sofia
Dominik Siemon, Sorour Khalili Narani, Kristin Ostermeier, Susanne Robra-Bissantz

Paper 23. ***Evaluating Anchored Discussion to Foster Creativity in Online Collaboration***
In Proceedings of the International Conference on Collaboration and Technology (CRIWG)
Georg J.P. Link, Dominik Siemon, Gert-Jan de Vreede, Susanne Robra-Bissantz

2014

Paper 24. ***Situation-oriented Ubiquitous Information System Innovation - Leveraging User Integration***
In Proceedings of the European Conference on Information Systems (ECIS)
Alexander Perl, Patrick Helmholz, Dominik Siemon, Sebastian Busse, Susanne Robra-Bissantz

Paper 25. ***Integration of Information Retrieval in Creativity Support - A Prototype to Support Divergent Thinking***
In Proceedings of the International Conference On Design Science Research In InformationSystems And Technology (DESRIST)
Dominik Siemon, Susanne Robra-Bissantz

1.2 Structure of the Dissertation

This dissertation is divided into seven parts and presents the author's research on IT-supported collaborative creativity. The first part (chapter 1) contains an introduction and presents the author's publications. The second part (chapter 2) contains the theoretical background on innovation, creativity and collaboration. Part three (chapter 3) provides the relevance of the thesis and the research gap, including an overall motivation for the research. This part reveals the lack of active IT support of collaborative creativity. The fourth part (chapter 4) presents the research method and the objectives of the conducted research. This part further includes an explanation of the the Design Science Research approach and a discussion of other relevant research methodologies. The fifth part (chapter 5) provides a comprehensive overview of the author's conducted research and publications. All publications are set in context and an explanation on the decision which publications are directly included in this dissertation is given.

The next four chapters, which is part six, present the publications that are directly integrated in the dissertation. Each publication is allocated to one or both research objectives. The final part seven (chapter 11) summarizes the findings and the main contribution of the research. Additionally, the part provides an outlook for future research and concludes with final remarks. The parts one to five and part seven are the framework of this dissertation, representing the foundation of this thesis, whereas part six, the publications, constitute the contribution of the thesis. Figure 1.1 presents an overview of the overall structure of the dissertation.

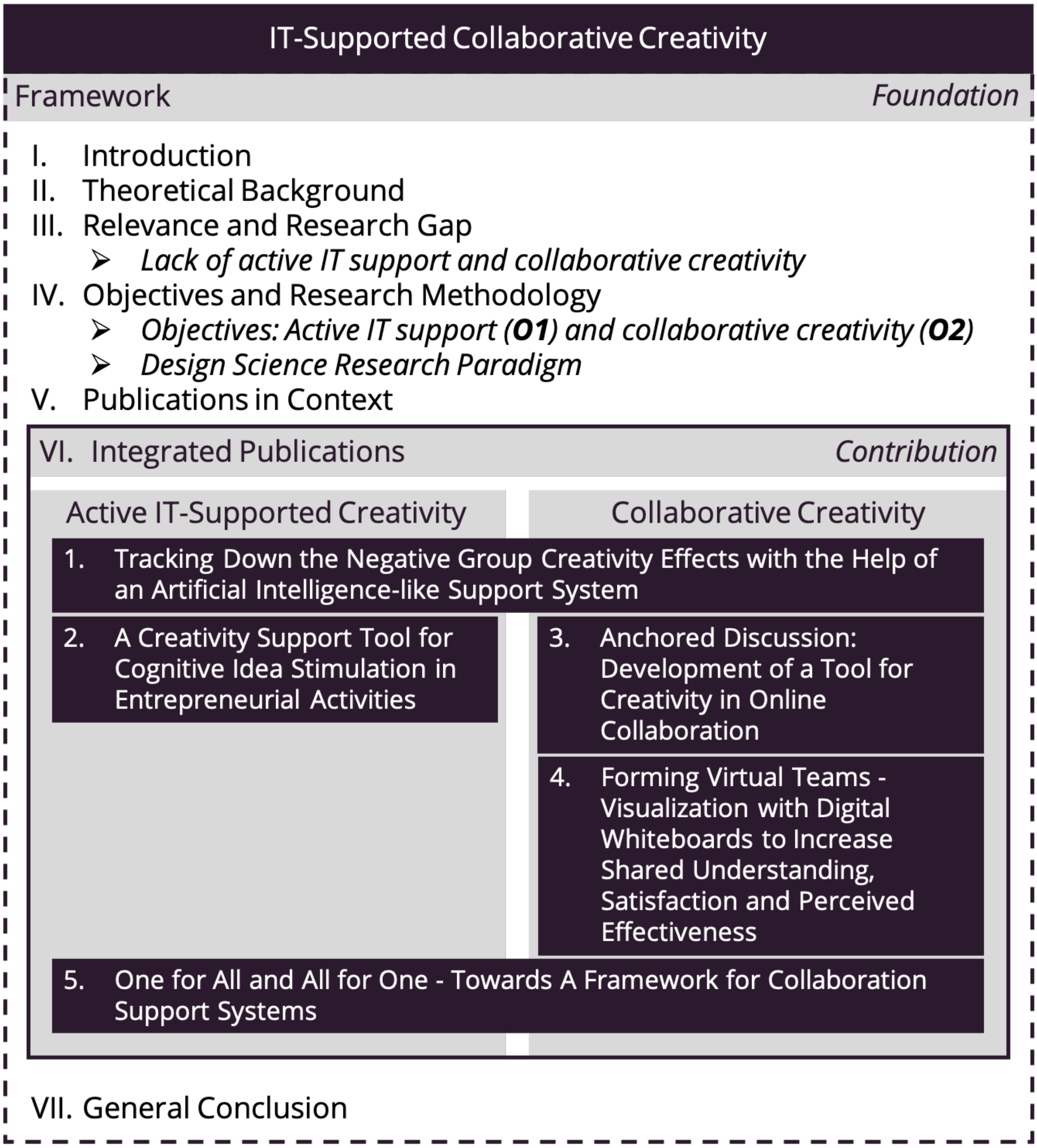

Figure 1.1: Structure of the Dissertation

2 Theoretical Background

In an increasingly connected world, the demands on organizations and companies to hold existing and win new customers, as well as to secure market shares, are growing. Digitization confronts companies with immense challenges but in contrast holds potential for an organizational transformation (Urbach and Ahlemann, 2016). An essential factor in this challenging environment are innovations that can create competitive advantages and thus ensure sustainable success (Weerawardena and Mavondo, 2011; Kung and Schmid, 2015). Companies and organizations therefore need innovative products and services, as well as superior methods for their development in order to respond to dynamic changes in markets and customer needs (Somech and Drach-Zahavy, 2013; Vahs and Brem, 2015). Not only established companies need to constantly innovate, but also young companies and start-ups trying to enter the market with new products or services. These new market participants give the competition an impetus and thus promote economic dynamics (McMullen and Shepherd, 2006) and an ongoing innovation process in the national and international economy (Baron and Shane, 2007). In particular, with the global economic upswing, the digitization, and the changing needs and values, there is a demand for creative entrepreneurs to develop disruptive solutions (McMullen and Shepherd, 2006). Although the globalization and digitization will create new business opportunities for companies and entrepreneurs, the pressure to remain competitive is increasing (Somech and Drach-Zahavy, 2013). Therefore it is particularly important to be innovative and produce new and innovative ideas as quickly as possible to differentiate from the competition.

2.1 Innovation and its Management

There are a number of different definitions of the concept of innovation in literature. According to the definition of Hauschildt et al. (2016), an innovation is a novel product, service or process that differs substantially from a previous state. In 1926, Schumpeter described an innovation as the implementation of new combinations of the things and forces available to us, which occur discontinuously and cause a creative destruction of the existing combinations (Schumpeter, 1934). It is the sustained enforcement and distribution within the company or the market, which distinguishes an innovation from an idea or invention, as depicted in figure 2.1 (Disselkamp, 2012; Lee et al., 2012; Vahs and Brem, 2015).

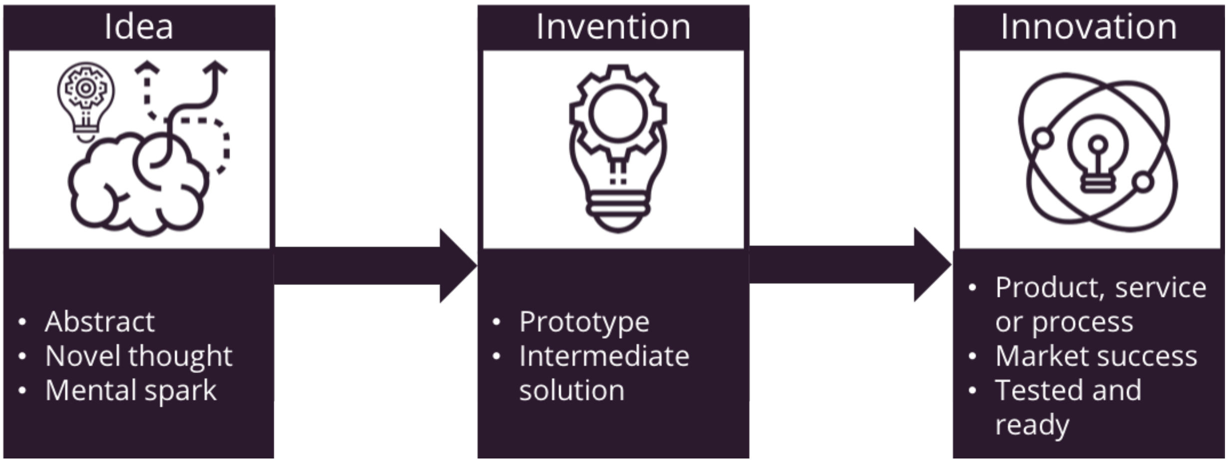

Figure 2.1: Characteristics of Ideas, Inventions and Innovations based on Hauschildt et al. (2016), Disselkamp (2012) and Lee et al. (2012)

Due to the financial and temporal expenditures associated with the innovation activities, it is necessary to establish an innovation process (Vahs and Brem, 2015). An innovation process or an innovation from a process-oriented perspective is a logical and, from a traditional perspective, time-related sequence of activities and decisions that should lead to a new product, service or the use of a new process (Disselkamp, 2012). This definition of an innovation process implies activities and decisions that are necessary to systematically come up with innovations. Within a company, the innovation process involves various stakeholders, that are responsible for the success of it. In view of the numerous challenges arising, for example, from the high uncertainty and complexity of innovations, and the economic striving of a company for a resource-efficient operation, a systematic planning, execution, coordination and monitoring of all innovation related processes is necessary (Vahs and Brem, 2015). Therefore, in a traditional perspective, it is important to establish a methodical innovation process, which is referred to as innovation management or management of innovation. Innovation management includes the systematic support of the entire innovation process from the generation of new ideas to their implementation into new products on the market (Disselkamp, 2012). According to Vahs and Brem (2015), innovation management includes "all planning, decision-making, organizational and control tasks with regard to the generation and implementation of new ideas into marketable services" (Vahs and Brem, 2015, p. 28). In addition, innovation management is also characterized as an acceptance management of new ideas (Schrader, 1991). For the description of innovation management, there are numerous different phase models that contain the activities needed to move from an idea to an innovation (Chesbrough, 2003). Over time, the understanding of innovation management has changed significantly. Among other things, they are evolving from simple, linear models to increasingly complex, interactive and iterative models that go far beyond a processual character (Tidd, 2006). Internal research and development was a valuable strategic advantage for companies (Chesbrough, 2013), where companies strived to acquire unique technological core competencies that were developed internally under complete seclusion in order to gain benefits as first mover in the market. The research and development department was thus the key resource for innovation and promoted a company's independent value chain (Lee et al., 2012). This approach of closed innovation forced companies to act holistically; from idea generation, development and production to marketing, sales and financing, all tasks were in the hands of one's own company. This philosophy of complete control of innovation implies entrepreneurial autonomy as a critical success factor: "If you want something done right, you've got to do it yourself" (Chesbrough, 2003, p. XX). This logic of research and development operations dominated many of the world's leading industrial companies for almost the entire 20th century. At the end of the 20th century, the philosophy of entrepreneurial autonomy increasingly developed into a practically impossible goal. The development of ideas into profitable innovations within the company's own boundaries has become increasingly ineffective. As a result, products and services were developed that did not address the values and needs of potential customers, but were developed on the basis of internal knowledge. Due to the constant digitization and the resulting interplay of companies and customers, it became possible to acquire knowledge and competencies outside of the company's own borders resulting in a reconsideration of the closed innovation approach (Chesbrough, 2003). This globalized marketplace and the advances in information and communication technology have enabled companies to find suitable collaborators and cooperators around the world. The classic approach of closed innovation had to be revised into a more open approach that considers the interplay and cooperation with other external stakeholders. The need to find partners to design innovations through a combination of their own core competencies is a logical consequence (Robra-Bissantz, 2018). Many new forms of partnerships, joint ventures or strategic alliances have experienced and are growing in popularity. Inter-company partnerships - based on joint innovation research - develop innovative value chains that can provide sustainable competitive advantages (Lee et al., 2012). This interconnectedness of the global economy and the possibilities for a broad exchange of knowledge, supported by information and communication technology, have allowed and permit a much broader cooperation and collaboration (Lee et al., 2012). To ultimately generate synergies between internal business processes and external knowledge, many companies began to apply the practices of the so-called open innovation, first introduced by Henry William Chesbrough in 2003, where collaboration is not limited to the inter-company level. Collaboration with multiple, diverse subjects such as external research institutes, universities, knowledge communities and especially customers (Lattemann and Robra-Bissantz, 2005) is made possible and becomes necessary. Open innovation is defined as a distributed innovation and idea generation process based on goal-oriented management of knowledge flows across organizational boundaries, using financial and non-financial mechanisms in line with the business model of the enterprise (Chesbrough et al., 2006). The co-innovation approach by Lee et al., presented in 2012 as a new innovation paradigm, addresses collaboration and value co-creation to give businesses the best value. Co-innovation provides a paradigm through which new ideas or approaches can be applied differently from a variety of internal and external sources to generate value or experience from which all stakeholders should benefit. The core of this co-innovation approach involves commitment, experience and co-creation to generate a value that is difficult to be imitated by competitors. In doing so, this innovation paradigm builds on the principle of convergence of ideas and expertise, collaborative arrangements of participating companies and co-creation of the value to be shared with additional help, for example from customers (Lee et al., 2012; Lattemann and Robra-Bissantz, 2005). The co-innovation paradigm is not limited to the development of new products, services or process (as open innovation), but also allows for disruptive business models or the founding of new companies (Lee et al., 2012). In a co-creation process, a company or group works collaboratively with all stakeholders to create value (Lee et al., 2012). Co-creation can be applied holistically along the value chain and in any industry (Leavy, 2012). Above all with the whole of the customers, co-creation is important as customers know best what they prefer and how products or services need to be changed to generate more customer value. The existence of an experiential mindset, fruitful interactions within the collective, a platform for engagement and network relations are the core elements of co-creation (Lee et al., 2012; Robra-Bissantz, 2018). Essentially, corporate customers should not only be integrated to create value for themselves, but with the additional incentive to create value for the community. Examples include value creation in social areas or sustainable environmental protection (Lee et al., 2012). Other mindsets similar to co-creation or often described as sub-categories of general human-centered approaches are Design Thinking or User-centered design, both of which focus on collaborative value creation by integrating the customers into the process (Singh, 2016). A strict differentiation between these approaches is not inevitably necessary and not always possible. The center of all these forms of innovation is an all-encompassing collaboration. This means, that all stakeholders do not only provide their requirements and needs for an innovation, but also distinctly contribute to the specific innovation. This distinguishes collaboration from cooperation, where labour is divided and cooperating partners work on different parts or objects that are then combined (Lee et al., 2012). However, all these approaches, regardless of the value of openness, involve the generation of ideas. A decisive factor for the development of ideas is creativity (Gassmann and Zeschky, 2008). Accordingly, the phase of generating and evaluating ideas is closely linked to creativity (Vahs and Brem, 2015). Creativity has been established as a critical factor with a direct influence on a business' success (Massetti, 1996). Researchers are confident about the fact that enhancing the creative output is the key for conquering external tensions, nourishing novelty and producing innovations (Amabile et al., 1996). This applies to countless professions and businesses, since innovation is set into motion through creative performance (Paulus et al., 2012). Therefore, in order to come up with valuable innovations, both start-ups and established companies must give more attention to creativity (Shalley et al., 2009).

2.2 Creativity and Creativity Support

Creativity is a widely used term, which is not clearly defined (Parkhurst, 1999; Runco, 2004). Creativity is an intangible term that can be associated with an outcome of a process, a person or a group, a process itself or an ability or way of thinking (Rhodes, 1961; Hennessey and Amabile, 2010). A well accepted definition by Amabile (1983) says, that a creative outcome is novel and appropriate, useful, correct or valuable to a specific task. In addition, creativity is an activity that is heuristic and therefore implies that a process is required. Within psychology, creativity is divided into four different components. Firstly, there is a differentiation between the creative process as an entity. Secondly, there is a separation of the output, the idea. On a third note, the individual carrying out the process is also analyzed, finalizing with the surroundings around the process, which are summed up into the term "environment" (Basadur et al., 2000; Howard et al., 2008). Rhodes (1961) defines these four perspectives as the four P's of creativity. These are, the acting person herself/himself (person), the creative process (process) and a resulting product (product). Thereby the person is exposed to, and is interacting with its environment, which Rhodes referred to as pressure (press). All four aspects influence each other and are in addition related to each other (Rhodes, 1961). Additional factors such as individual ability, the nature of the decision task, the amount of training, and the technology used also affects creative performance (Ivcevic and Mayer, 2006). For novel concepts to originate, the ability to analyze aspects using remote association, as well as other free-flowing and non-linear thinking ways is beneficial, which is known as divergent thinking (de Bono, 2015). Divergent thinking is often used as a level to measure the creative ability of an individual. It encompasses a manner of thinking, that does not concentrate on one approach, rather allowing for different directions of thought. Divergent thinking defines an individual's idea fluency, referring to the amount, value and newness of ideas (Jauk et al., 2013). The opposite of divergent thinking is convergent thinking, which is commonly linked to tasks requiring inhibition of alternate thoughts, leading to an individual being concentrated on one idea at a time, leading to a process with low flexibility (Chermahini and Hommel, 2012). Convergent thinking focuses on deriving a single, well-established idea, accentuates logic, accuracy and emphasizes on techniques to concentrate on specific aspects of an idea like workability, relevance, and specificity (Runco and Acar, 2012). Creativity is understood as an iterative interaction between convergent thinking and divergent thinking (Finke et al., 1996). Figure 2.2 illustrates the comprehensive concept of creativity.

Improving creativity of individuals has been attempted by seeking to enhance creative processes. Traditional methods include a shift in the way a person understands and solves a task (Kozbelt et al., 2010). These creativity techniques intend to improve the creative outcome by altering the creative process, as this process is the main factor influencing the creative product (Herring et al., 2009; Gassmann and Zeschky, 2008). Numerous creativity techniques have been developed and are common practices in daily business (Fischer et al., 2005). With the help of IT, a variety of creativity techniques have already been digitized. These digitized techniques

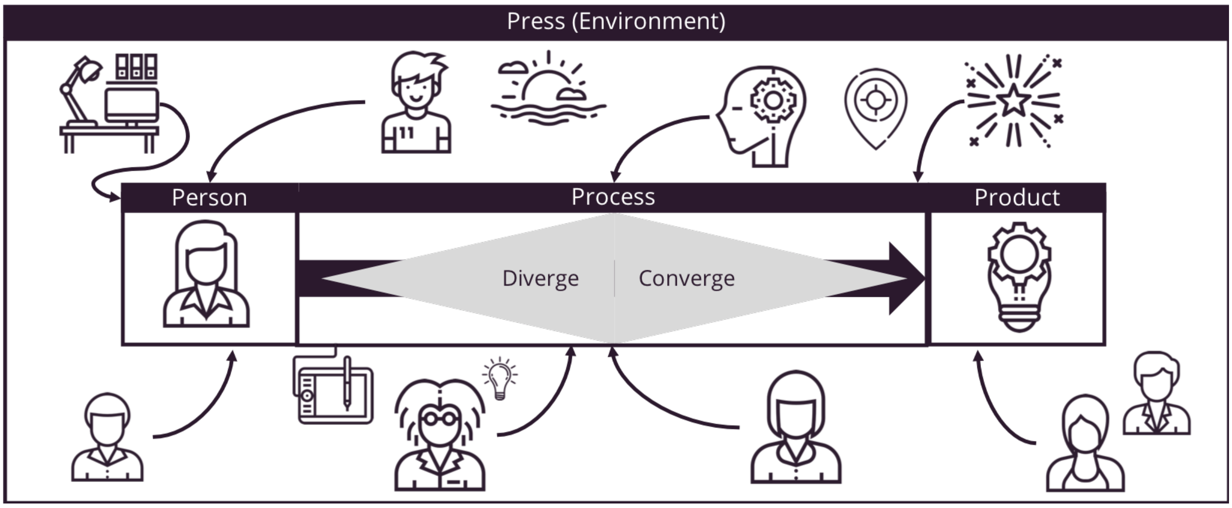

Figure 2.2: The Concept of Creativity based on Rhodes (1961), Runco (2004), and Hennessey and Amabile (2010)

aim to further support the creative process, by using different mechanisms and functionality that IT offers.

2.3 IT-Supported Creativity

Computer programs or systems are capable of aiding users to complete tasks in various fields, ranging from engineering tasks, medical services and decision support to knowledge management support (Power and Sharda, 2009; Kraemer and King, 1988). Socio-technical systems in which IT is used to support people in performing certain tasks are called IS. IS can thus be defined as systems consisting of humans, tasks and technologies (hardware and software) that produce, distribute and process data (or information) (Heinrich et al., 2011). IS have been designed for tasks in which creativity is necessary. These include science studies, literary work, musical work and depiction, design, mathematics and art (Colton and Wiggins, 2012). IS that support creativity are called Creativity Support System (CSS) or Creativity Support Tool (CST). Even though, few researchers distinguish between these two definitions (Gabriel et al., 2016), in the context of this dissertation, both terms are used synonymously. Furthermore, CSS can be categorized into Individual Creativity Support System (ICSS) and Group Creativity Support System (GCSS). ICSS deal with individuals during a creative process, whereas GCSS use IT to combine the abilities and experiences of a group. In ICSS, group effects are excluded and the focus is set on the creative process of an individual and how she/he can be supported (Wang and Nickerson, 2017). However, both, ICSS and GCSS focus on creative activities that seek to invigorate their users in their creative process, either individually or collectively (Shneiderman, 2007). The aim of CSS is to enhance creativity by stimulating and documenting creative processes. The role of the IT, however, can be threefold. IT can take on an administrative role, a supporting role or an active and producing role. In the case of creativity support, IT can help to manage, store or organize ideas (administrative role), support the user in carrying out specific tasks, e.g. creativity techniques (supporting role) or actively contribute to the problem solving with its own content or solutions (producing role). This role of the IT and the specific needs on how IT should be designed to foster creativity has led to a number of research, analyzing various theories and systems, resulting in the proposal of principles and guidelines for designers and developers on how to design CSS (Resnick et al., 2005; Seidel et al., 2010; Voigt and Bergener, 2013; Althuizen and Reichel, 2016; Wang and Nickerson, 2017). However, one main aspect remains in all research: There is no all-encompassing CSS and never a solely applicable CSS for a comprehensive task. The use of a CSS has to be chosen according to the task, the context, the environment and the requirements. Another important aspect is that even though ICSS aim to support individuals, the use of ICSS in a group or team context can also be beneficial. Despite the fact that ICSS aim to support solely individuals, this individual support can be applicable in a group setting, where it is important to support both (e.g. sequential), creativity on an individual level and on a collective level. Nonetheless, when applying ICSS or GCSS the interplay between individuals is of special interest, as solutions for complex problems are easier to achieve when people work in groups or teams (Lurey and Raisinghani, 2001). Research on the advantages of team work identified that being in contact with other individuals, who have different points of view can incite creative thoughts in new subjects (Paulus et al., 2012). Researchers have demonstrated that group ideation can lead to superior outcomes regarding the value and the number of created ideas (Paulus and Nijstad, 2009). CSS therefore have to specifically apply mechanisms and functions of collaboration to provide a most beneficial support for creative processes.

2.4 Collaboration

Cooperation and collaboration are similar terms, yet they are not interchangeable (Bornemann, 2012; Stadermann, 2011). Both, however involve the aim to reach a common goal, using the potential of a collective. Cooperation is the process of individuals working or acting together for common or mutual benefits, as opposed to working in competition for selfish benefits. Cooperation is characterized by two or more stakeholders, who have determined to work together to achieve a common goal. However, cooperation does not mean, that all stakeholders are working on the same object or aspect to achieve the common goal. In the context of an organization this means, that different departments work on different objects or parts to achieve a common goal. By doing so, the departments have to mutually work together and depend on each other to reach the goal. In contrast, collaboration means that two or more stakeholder work on one specific object or entity that is collectively created to achieve a common goal (see figure 2.3). Examples of collaboration can be found in the generation of art, music or ideas, as the stakeholders work on the specific object, e.g. a song, a painting or another form of idea. Due to the high synergetic effects in collaboration, so-called non-summative processes are supported, which in total are more than all individual parts (Bornemann, 2012; Paulus et al., 2012). Bornemann (2012) compares collaboration with lateral patterns of thinking and shows that the inner continuity of one's own logic of thought is broken by the confrontation with other logic of thought. Collaborative processes are therefore a necessary aspect for the originality of an idea.

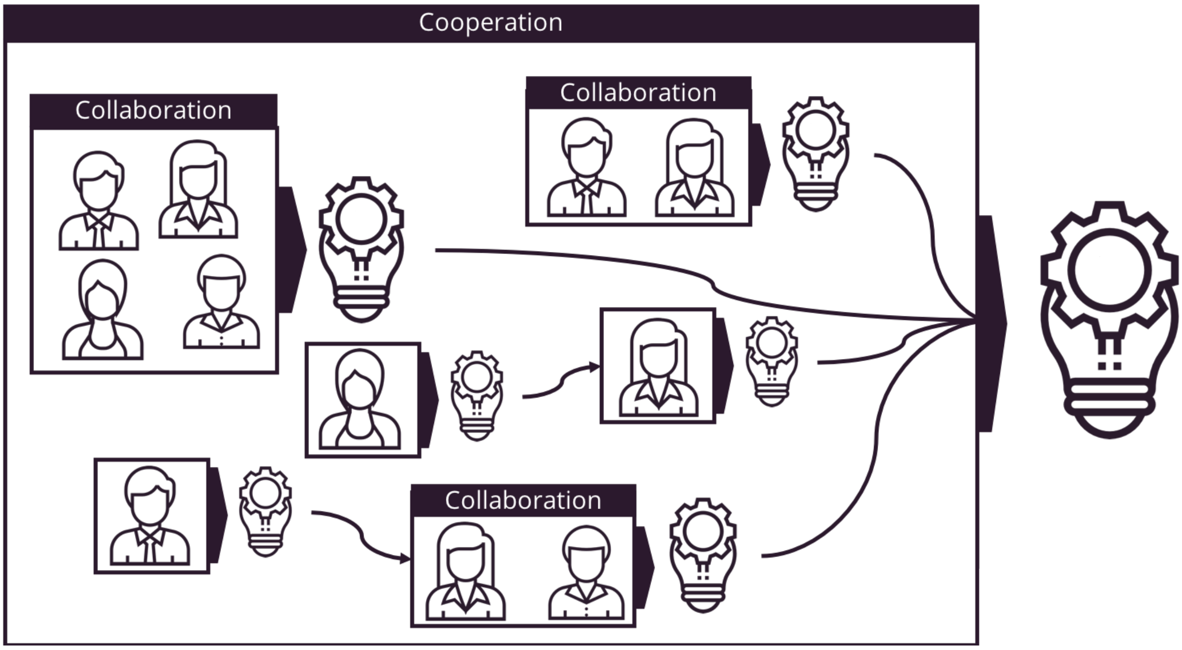

Figure 2.3: Cooperation and Collaboration based on Bornemann (2012, p. 77)

"Collaboration can occur in any domain where people seek to create value together" (Randrup et al., 2016, p. 900) and is based on a variety of comprehensive concepts and principles. This definition already depicts the two main aspects of collaboration: a common goal and the collective effort to achieve the common goal. Having and pursuing a common goal is the key to successful collaboration and, in turn, motivates every member of the group (Briggs et al., 2008). In their paper "Philosophy of Collaboration", Randrup et al. (2016) describe this as benevolence, where "collaborators should not intentionally work against the attainment of the group goals and should negotiate in good faith to accommodate the private goals that motivate individual member participation in the collaboration." (Randrup et al., 2016, p. 904). The attainment of the goal produces happiness and satisfaction for every individual and in addition motivates to collaborate (i.e. leads to commitment), which strives individuals to work together and fulfill even individual needs (Briggs et al., 2008). This can be explained by the Yield Shift Theory of Satisfaction, which states that, "the more likely people perceive they are to attain their goals, the more positive their satisfaction responses" (Randrup et al., 2016, p. 900). Randrup et al. (2016) describe the total commitment of every member as obligation, whereby collaborators should expand sufficient effort. That in turn means that everyone should not withhold any input and openly and honestly contribute.

Reciprocity, the notion of obligation within the collective nature means, that when one group member is more involved in the effort, the other group members return the effort when needed. (Barczak et al., 2010; Kasper-Fuehrera and Ashkanasy, 2001; Bijlsma and Koopman, 2003; Randrup et al., 2016). Another important aspect of collaboration is trust. Trust within a group fosters group work in various ways, such as the willingness to share knowledge or the provision of individual resources (Barczak et al., 2010; Kasper-Fuehrera and Ashkanasy, 2001; Bijlsma and Koopman, 2003; Randrup et al., 2016; Cheng et al., 2016). "Trust acts as a facilitator and promotes interpersonal relationships prompting people to seek and give help leading to a more collaborative culture." (Barczak et al., 2010, p. 335). Trust is therefore already positively linked to group performance and creativity. Trust, however requires and implies mutual respect (Kadefors, 2004). Mutual respect means that every group member's voice should have the same value and every opinion should be respected (Ryan and Viete, 2009). In organizations and companies this means the establishment of a heterarchic structure. Creating team trust is therefore indispensable. One way to create trust is by Team Emotional Intelligence (TEI). TEI is the "ability of a group to develop a set of norms that manage emotional processes" (Druskat and Wolff, 2001, p. 133), which facilitates collaboration. These norms state that each group member is aware of their own emotions and the emotions of the team. This creates a better interaction, reduces team conflicts, and thus creates stronger relationships leading to team cohesiveness (Barczak et al., 2010; Druskat and Wolff, 2001). Beside of trust, motivation is inevitable for collaboration. However, team trust can enhance motivation to collaborate, the drive for happiness, and satisfaction to reach a common goal, which motivates individuals as well. This can be described and explained by value creation, which means the creation of a common value. This value can be either a valuable outcome or the mutual creation e.g. the collaboration itself, which brings satisfaction and happiness (Randrup et al., 2016; Robra-Bissantz, 2018). In summary, collaboration requires a number of aspects or principles that must be adhered in order to effectively collaborate:

- Reciprocity
- Common goal
- Trust and mutual respect
- Group awareness and Team Emotional Intelligence
- Benevolence and commitment
- Cohesiveness

Reaching this collaborative culture is however not as unpretentious as these principles state. Especially in creativity-intensive processes, in which collaboration involves creativity influencing factors on a cognitive and social level, these principles need to be adhered and specifically supported.

2.5 Collaborative Creativity

Collaborative creativity can be defined as the generation of ideas in a collective manner with the uphold of the principles of collaboration (Paulus et al., 2012). Based on the definition of collaboration, the mutual value creation should be without the division of labour to secure the high synergetic effects of the collective. When generating ideas individually, the creative abilities are restricted to the single individual that creates the idea and the environment that the person is in. This environment, as described by various researchers, can influence the creative process on a cognitive level. Various so-called stimuli can enhance or impair the creative process and subsequently the creative outcome (the idea). In a group or team context, not only cognitive stimuli can influence the individuals, but additionally social factors have an effect on the creative process. This is called the synergetic effect that goes beyond the sole sum of each individuals performance (Paulus et al., 2012; Tasa et al., 2007; Busch and von der Oelsnitz, 2016). Factors influencing team and group performance can on the one hand support the creative process, like mutual motivation or mental leaps and new associations based on interaction. On the other hand, the creative process can be impaired due to cognitive overload or production blocking. Therefore, collaborative creativity is not only the sum of every individual's creativity (including the individual knowledge, skills and abilities) but also the cognitive and social influence of the collective (Bornemann, 2012; Paulus et al., 2012). This can be described with a simple equation stated by Hackman and Morris (1975) explaining the actual group performance.

```
AGP = GP - PL + PG
AGP: Actual Group Performance,
GP: Group Potential,
PL: Process Loss,
PG: Process Gain
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Hackman and Morris (1975) described the actual group performance as the sum of the individual abilities/performance (GP) minus the process losses plus the process gains. Process losses describe the negative cognitive and social factors within a collective performance. The process gains however, describe the positive influencing factors that the collective brings with it. This equation can be adapted to collaboration, where different mechanisms shape the factors process losses and process gains. Within collaboration and especially collaborative creativity, group performance represents the members individual creative performance and the process losses and gains are shaped by the interaction within the collective. In order to reach an effective actual collaborative creativity, the process losses have to be minimized and the process gains have to be maximized. Sonnenburg (2007) describes collaborative creativity (or analogously cooperative creativity) as an idealistic type of creativity, where interaction is the driving force for mutual stimulation that is responsible for the enhancement of the overall creativity. This is equivalent to the process gains in a collaborative creativity setting or the high synergetic effects of a collaboration. However, an effective collaborative creativity depends on a variety of factors, mechanisms and individual characteristics and can therefore not simply be represented as a rudimentary equation. Designing and developing IT that supports collaborative creativity is therefore especially challenging as specific functionality to support process gains need to be defined and tested. In team and group constellations, design guidelines for IT to support collective creativity have already been proposed (Resnick et al., 2005; Voigt and Bergener, 2013). These guidelines however, focus on the characteristics of groups or teams and neglect the specifics of collaboration. IT that specifically supports collaborative creativity therefore needs appropriate guidelines and functions, which yet have not been defined.

3 Relevance and Motivation

Research on CSS and case studies of CSS implemented in organizations have a long tradition (Gabriel et al., 2016). As one of the first, Nunamaker et al. (1987) defined Electronic Meeting Systems, where users could electronically brainstorm. Later the term Electronic Brainstorming was used and one of the first CSS was defined in research (Nunamaker et al., 1991). In 1996, Massetti published an article in the MIS Quarterly, assessing the value of CSS on idea generation (Massetti, 1996). Since then, more research has been published, examining the impact and benefits of CSS, followed by the development of a variety of artifacts of IT-supported creativity. By now, research established a number of theories and mechanism how CSS should be designed for the most beneficial impact (Voigt et al., 2013a). However, two main areas are still little or not fully investigated: CSS that support collaborative creativity and CSS that use IT to actively support the creative process. In this section, a systematic literature review and a qualitative analysis of IT-supported innovation processes of companies (based on students theses) reveal a research gap and the relevance for this dissertation.

3.1 Related Work and State of the Art

The degree of IT in a CSS can differ essentially in three ways. First, IT can help to manage and organize ideas (manage), second, support the users by providing communication features or with specific creativity techniques (support). Third, IT can actively contribute to the creativity process (produce). In the context of CSS, Lubart (2005) divided the support provided by the CSS into four categories and figuratively named them: Computers as a nanny, as a pen-pal, as a coach or as a colleague (see figure 3.1). The nanny supports by monitoring the creative process, setting agendas and deadlines. The pen-pal helps by providing the possibility to receive, compose and distribute an idea. Additionally, the support of communication features is provided. The coach represents a support system that helps with a specific method or with the system itself. The systems supports by recommending other methods or steps within idea generation. All these systems represent passive systems, that interact with the user, but only provide assistance by organizing ideas, planning activities, providing necessary tools (e.g. a notepad), supporting communication or assisting with creativity techniques. The computer as a colleague is the only concept that can be described as an active support, where IT is used to provide creative thoughts, random or semi-random stimuli and play a human role (Lubart, 2005). For the context of this dissertation the computer as a colleague as defined by Lubart (2005) is relevant. The computer as a nanny, a pen-pal or a coach can be attributed to idea management systems, where no active input is provided by the system (Westerski, 2013; Gabriel et al., 2016). The purpose of idea management systems is for users to develop ideas on their own, enter the ideas into the system, consider ideas from peers for further development and carry out projects based on matured ideas (Pundt and Schyns, 2005). Figure 3.1 provides an overview of the classification of CSS by Lubart (2005).

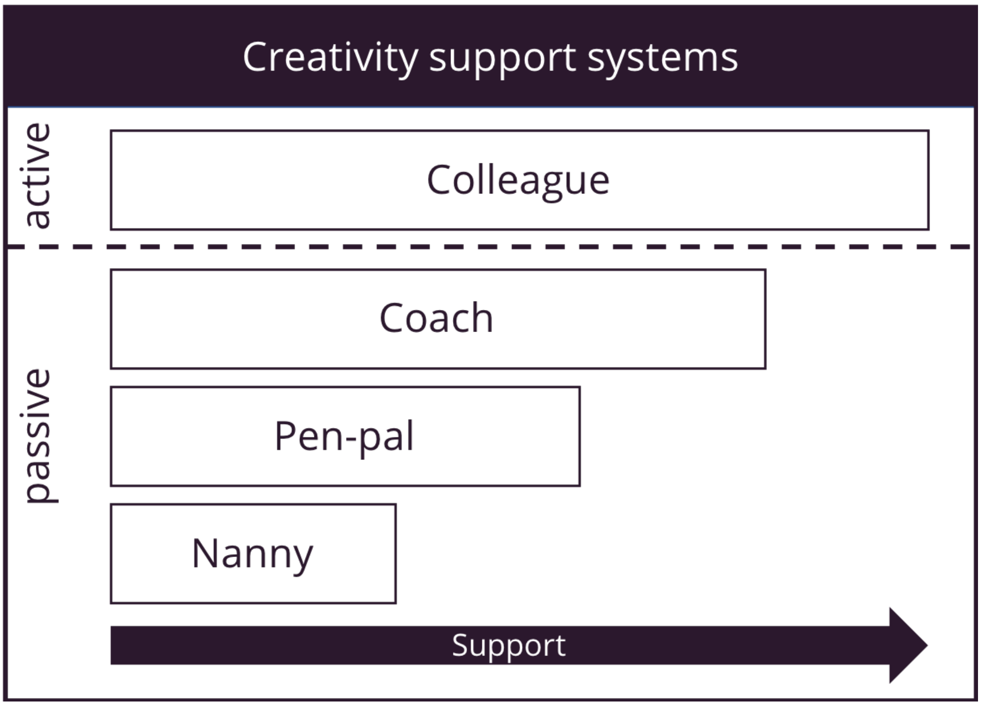

Figure 3.1: Classification of Creativity Support Systems based on Lubart (2005)

Active support means that the CSS is able to identify the context and phase in which the user is located and then provide the information that is most helpful to the user (Davis et al., 2013). Additionally, active support means that the system provides new content, that can expand the solution space of the user. Thus, actively providing stimuli or other supporting content that enhances the creativity process. A similar concept and term of active IT is autonomous IS, which describes systems that do not only take action in response to a user's action. Traditional IS is "passive, i. e., data or knowledge is created, retrieved, modified, updated, and deleted only in response to operations issued by users" (Cheng, 2001, p. 333). In contrast to that, autonomous IS serves as a partner and discovers new content on its own, thus has the ability to do something actively by itself (Cheng, 2001). Authors argue that this active support is more beneficial compared to solely process guides, visualization or other passive support (Boden, 2009; Althuizen and Reichel, 2016). In the context of this dissertation, we define active IT-supported creativity as followed: A system that autonomously supports a user or a group, provides new supporting content (e.g. stimuli or thoughts) that expands the solutions space and further develops the ideas of the user of the system. With the introduction of Electronic

Brainstorming, group effects that enhance, but also impair creativity have been examined. For example, early research provides evidence that anonymity is beneficial for group creativity, as social factors like evaluation apprehensions (e.g. fear of critics) can be reduced or eliminated (Connolly et al., 1990). More studies followed and examined other cognitive or social factors like free-riding, social loafing, evaluation apprehension and the Collective Effort Model (CEM). However, most studies focus on group effects and provide design principles and guidelines on how to design and develop such GCSS (Bawden, 1986; Gabriel et al., 2016; Hilliges et al., 2007; Nunamaker et al., 1987; Resnick et al., 2005; Voigt and Bergener, 2013). These guidelines focus on group effects and how general interaction, like communication and knowledge sharing should be designed. Specific mechanisms and principles for collaboration are neglected and collaborative creativity as defined in section 2.5 is a rarely covered topic. Through this two perspectives of CSS, the degree of IT support and the adherence to collaboration principles, the current state of research can be systematically analyzed. Both aspects represent different characteristics, which can be pursued in IT-supported creativity. CSS should subsequently pursue both aspects in order to achieve an all-encompassing benefit from collaboration and active IT support.

3.2 Literature Review

To reveal the current research gap, a systematic literature review provides an overview of the state-of-the-art of IT-supported collaborative creativity. Literature was analyzed according to their degree of active IT support and their collaboration support. As not all CSS are actively supportive and not all CSS use collaboration mechanisms, the existing literature was assessed as followed: Different search terms were used to identify literature covering CSS. The identified CSS will be tested regarding their implementation of collaboration functions. Subsequently, CSS were clustered into either collective or individual CSS. Then, the systems were analyzed to determine if they provide active support. Systems that prompt the further development of ideas or create more ideas autonomously are of interest. The systems using collaboration functions were furthermore analyzed towards their underlying collaboration principles. Figure 3.2 presents an overview of the literature review procedure.

To determine the extent of existing CSS to actively support users during the creative process and whether collaboration functions are implemented, the existing literature will be reviewed according to the PRISMA method, as presented by Moher et al. (2010). The preferred reporting items for systematic review and meta-analysis protocols (PRISMA model) is a methodology to report on meta-analysis through systematic reviews. A systematic review begins with a clearly formulated research purpose. Existing literature is methodically analyzed to determine, select and critically review information. Relevant findings from previous studies are then incorporated into the review (Moher et al., 2010). The PRISMA reporting method has

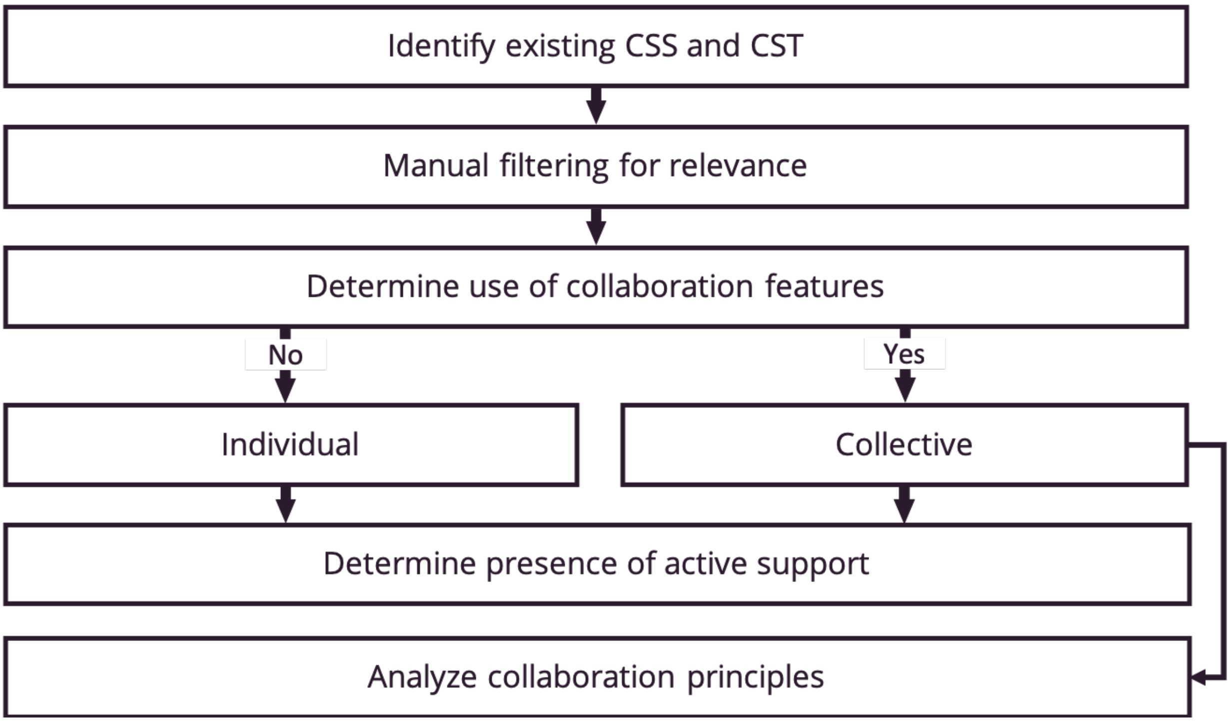

Figure 3.2: Literature Review Procedure

proven useful in various disciplines, due to peer-reviewed articles being thoroughly documented (Booth et al., 2016). To be able to commence the study, keywords had to be selected. For this purpose, available literature on creativity, support systems and tools, as well as collaboration support was revised. Relevant keywords were collected in relation to the relevance of results, the methodology used and the actuality of studies. The gathered keywords were extended by seeking out synonyms. To identify relevant literature on CSS, information was sought out through three main databases: **Science Direct**, **ACM Digital Library** and **Scopus**. The search was not limited to specific research disciplines, as publications about CSS can be found in a variety of disciplines (Gabriel et al., 2016; Wang and Nickerson, 2017). Keywords were selected methodically based on existing and established literature and divided into two terms. The first term is "creativity", whereas the second term is "support system" and the synonyms "support tool" and "support software". This led to overall three different queries, which were executed in quotation marks, forcing an exact use of the terms. This was done to prevent finding articles where the terms are used in another context, like for example articles with a sentence like "A group of football players were able to develop a **system** that required **creativity** to **support** team performance", which contains the terms "creativity support system". This lowered the search results substantially and best fulfilled the purpose of the literature review, to only find systems, tools and software that support creativity. Further research papers were identified through forward and backward citations. The following code exemplarily presents the query for the ACM Digital Library. The same query was used for Scopus and Science Direct with the syntax adjusted accordingly.

```
"query": {("Creativity Support System" "Creativity Support
Tool" "Creativity Support Software")}
```

It should be noted that the systematic literature review was carried out in 2016, so that later published articles are not considered. Overall 494 articles were found, whereas the queries resulted in 131 articles from the ACM Digital Library, 96 articles from Science Direct and 267 from Scopus. In a second step, duplicates and incomplete/failed entries were eliminated, resulting in 267 articles. These articles were either written in English or German and all belong to books, journal articles and conference proceedings. In the next step, all articles were manually filtered and articles that do not describe an actual IS or that do not contain substantial information about the system's functionality were excluded. This means, that frameworks, meta-analysis, workshop reports, doctoral consortium paper, models, scales or guidelines about CSS were also excluded. Manual filtering was done by first reading the title and the abstract, leading to the exclusion of 101 articles. After reading the full paper and examining whether relevant information about the system is provided, 47 articles remained that contained 56 CSS (an article can cover multiple CSS). Table 3.1 presents the full list of all analyzed publications and CSS.

System Name	CSS Type	Active	Collaboration	Source
BrainDump	Individual	No	No	Brade et al. (2011)
BRIDGE	Group	No	Yes	Farooq et al. (2005) and Farooq et al. (2008)
CACDP	Individual	No	No	Liu et al. (2011)
Calico	Group	No	Yes	Mangano et al. (2010)
Caretta	Group	No	Yes	Warr and O'Neill (2007)
CBDS (abbrv.)	Individual/ Group	(Yes)	Yes	Yuan and Chen (2008)
Colab	Group	No	No	Stefik et al. (1987)
CombinFormation	Individual	No	No	Koh et al. (2007) and Kerne et al. (2008)
Creative virtual environment	Individual	No	No	Bhagwatwar et al. (2013)
Daisyfield	Individual/ Group	No	Yes	Bryan-Kinns (2013)
Dane	Individual	No	No	Vattam et al. (2011)
Dazzle	Group	No	Yes	Oehlberg et al. (2012)
E-Brainstorming	Group	No	Yes	Gutwein (2013)

System Name	CSS Type	Active	Collaboration	Source
En Passant 2	Individual	No	No	Aihara and Hori (1998)
Envisionment and Discovery Collaboratory	Group	No	Yes	Warr and O'Neill (2007)
EVIDII	Individual/ Group	No	No	Farooq et al. (2005)
Firestorm	Group	No	Yes	Gutwein (2013)
FISH	Individual	(Yes)	No	Indurkhya et al. (2008)
GADjet	Group	No	Yes	Gutwein (2013)
GAE	Group	No	Yes	Liu et al. (2011)
Galaxy	Individual	(Yes)	No	Wang and Ohsawa (2013)
Gi2MO	Individual	No	Yes	Westerski (2013)
GRAPE	Group	No	Yes	Kunifuji and Kato (2007)
i-Land	Individual/ Group	No	Yes	Warr and O'Neill (2007)
Idea Expander	Individual/ Group	(Yes)	Yes	Wang et al. (2010)
Idea Storming Cube	Group	No	Yes	Huang et al. (2007)
Idea-Inspire	Individual	No	No	Vattam et al. (2011)
IdeaCrepe	Individual	No	No	Nakazono et al. (2006)
Ideahound	Group	No	Yes	Siangliulue et al. (2016)
IdeaManager and iBox	Individual/ Group	No	Yes	Shibata and Hori (2003)
IdeaStream	Individual	No	Yes	Forster (2009)
IdeaVis	Group	No	Yes	Geyer et al. (2010)
idSpace	Group	No	Yes	van Rosmalen et al. (2014)
IIAAM (abbrv.)	Individual	No	No	Griffin and Jacob (2013)
iLounge	Group	No	Yes	Gutwein (2013)
Interactive art	Individual	No	No	Farooq et al. (2005)
Interactive system	Individual	No	No	de Rooij et al. (2015)
iRoom	Group	No	Yes	Gutwein (2013)
Laboranova	Individual	No	Yes	Hesmer et al. (2011)

System Name	CSS Type	Active	Collaboration	Source
ModLab	Individual/ Group	No	Yes	Carell and Herrmann (2010)
Momentum	Individual	No	No	Gutwein (2013)
No name	Individual	No	No	Sugimoto et al. (1996)
OctoProz	Group	No	Yes	Voigt et al. (2013b)
Pictionaire	Group	No	Yes	Hartmann et al. (2010)
Presemo Brainstormer	Individual/ Group	No	Yes	Liikkanen et al. (2011)
PromONTotion	Individual	No	Yes	Kermanidis et al. (2013)
Tatin-Pic	Individual/ Group	No	Yes	Jones et al. (2011)
TeamStorm	Individual/ Group	No	Yes	Hailpern et al. (2007)
Traces	Group	No	Yes	van Dijk and Vos (2011)
TRENDS	Individual	Yes	No	Setchi and Bouchard (2010) and Kim et al. (2012)
TRIZAcquisition	Individual	No	No	Cavallucci et al. (2011)
USE	Individual	(Yes)	No	Lopes et al. (2009)
Virtual Reality Mechanism Design Studio	Individual	No	No	Alvarez and Su (2012)
VisuaPedia	Individual	No	Yes	Tripathi et al. (2009)
Wikideas and Creativity Connector	Individual	No	Yes	Ardaiz et al. (2008)
WordPlay	Group	No	Yes	Gutwein (2013)

Table 3.1: Identified and Analyzed Creativity Support Systems

Consequently, the selected systems were characterized respecting their relevant characteristics. Trial- or free versions of the systems were tested, as far as available and also documentations of the software and tutorials are taken into account for the evaluation.

3.3 Results of the Literature Review

From the 56 identified CSS, 25 are solely supporting individual creativity, 21 focus on group creativity and 10 support both. Some authors presented systems as CSS, which, due to their limited creativity support, can be considered as idea management systems. Such systems are BrainDump, CACDP, or Envisionment and Discovery Collaboratory. These systems are unable to provide active support for individuals, since they only serve to present and arrange information. In the classification of Lubart (2005), these systems can be considered as nanny or pen-pal. Additionally, a number of identified CSS focus on enhancing brainstorming session, such as E-Brainstorming, Idea Expander or USE and specify on the unique characteristics of this creativity technique. As these systems help with a specific creativity technique, they can be considered as coach (Lubart, 2005). CSS that to some extent actively support the user are the systems TRENDS, USE, Idea Expander, CBDS, Galaxy and FISH. However, CBDS and FISH are only of conceptual nature and are no implemented computer software. The system Galaxy can be considered as active, as it independently reminds participants of a brainstorming sessions when they weren't active for a specific time. The system however, does not support the actual idea generation by providing additional information or beneficial stimuli. USE is a CSS that visualizes user generated content and adds connections to the concept of an idea. The aim of USE is to aid the user to find new conceptual links. However, the data used for this visualization is provided by the user, wherefore, due to the above stated definition, it cannot be considered as a system that provides new beneficial stimuli. A similar approach follows the system TRENDS. With TRENDS however, data is automatically provided by the system based on words that a user used. The system provides possible new stimulating images based on a degree of serendipity within the algorithm. The system Idea Expander uses an image database to provide visual stimuli to participants of a brainstorming session according to the topics being discussed. This, according to the stated definition, cannot be considered as active support as it solely uses words that are used within the conversation to query images. This process is to be equivalent to the use of an image search by the user. Therefore, only TRENDS can be considered as an active CSS e.g. a system as a collegue (Lubart, 2005) that provides new information and possible beneficial stimuli. In this case, IT has in fact a producing role within the CSS. In summary, from 56 analyzed CSS, only six CSS follow an active IT support approach, whereas five of these systems are either of conceptual nature or do not support the actual idea generation. Therefore, only one system, TRENDS, can be considered as an active CSS, as defined. In a next step, the CSS that include collaboration functions were analyzed considering their compliance with the principles of collaboration. Due to the fact that these principles of collaboration are defined in an abstractly-conceptional way and are not operationalized, it is difficult to examine whether a system complies with one or more of the principles. Therefore, the CSS that include collaboration features will be analyzed whether a system can be built on one or more of these principles without explicitly mentioning this or whether any functions or mechanism counteract to the principles. Although the explicit operationalization of the principles of collaboration is different for each CSS, the previously identified 21 CSS that implement collaboration features and the 10 CSS that focus on individual and collaboration are parsed accordingly. To assess, whether a system meets the requirements, only functions that are implemented within the software or directly connected to it are considered. Agreements that may be made by the group outside the system (e.g. analog collaboration) are not taken into account when evaluating a principle. The report of the analysis will be done in a sequential manner according to the degree or richness of the collaboration features, starting with systems that only include few collaboration features to systems that include comprehensive features. The basic requirement of collaboration is the possibility of a system to allow users to communicate (e.g. a chat function) and the possibility to share ideas and thoughts to other group members. All 31 systems include communication features to some degree. The majority, especially the systems focusing on electronic brainstorming, allow digital communication via a chat (e.g. E-Brainstorming or USE). Other systems go further and allow for sharing ideas (e.g. Colab or Crowdboard) or even providing a shared workspace, where the synchronous idea generation is possible (e.g. BRIDGE, Calico or Titan-Pic). This enhances mutual idea stimulation, between the members (Voigt and Bergener, 2013). However, many other CSS focus on the division of labour by splitting the idea into different aspects and tasks (e.g. Colab, E-Brainstorming or InnovationCast), allocating them to the members. The division of labour is more common in cooperation scenarios. Setting a common goal and having the commitment to reach it, are a prerequisites for a good collaboration. The systems GRAPE and Idea Storming Cube support the creation of a common goal by explicitly mentioning one or multiple common goals to be agreed on before starting with the idea generation. However, none of the systems uses mechanisms if the ideas of a member corrupt the common goal or measures how taken actions have an effect on the common goal. Besides these two CSS, no other system explicitly fosters the creation of a common goal at any point. CSS should be designed to enhance the process gains and to lower the processes losses. The analyzed systems rely on features like anonymity or the tracing of decisions to foster the overall collaboration. However, the use of anonymity counteracts to the building of trust, group awareness and cohesiveness (Hilliges et al., 2007). Systems like Presemo Brainstormer or Momentum use this mechanism, that furthermore hinders the building of TEI. Instead of using mechanism to foster reciprocity, the systems GRAPE and Idea Storming Cube build on mechanisms like competition and hierarchy (the use of task coordinator, allocator or higher-exposed group member to control the ideation process) which produces peer pressure instead of reciprocity, mutual respect or trust. No analyzed system explicitly fosters the enhancement of group awareness and overall cohesiveness. The collaboration aspect within the CSS are more or less used to accelerate the process of collecting and organizing ideas. Ideas are usually generated individually and then shared within a group. Thus, no collaboration, considering the principles of collaboration, takes place. In summary, the majority of the CSS that use collaboration features, use simple functions, like a chat, where users can communicate with each other. Another aspect is the synchronous work on a specific idea, e.g. a shared working space like a whiteboard or a digital document. Other systems however, focus more on the division of labour (GAE or GRAPE) and a subsequent merging of the individual aspects. This can be considered as cooperation. In terms of building trust, TEI and establishing group awareness, no analyzed system implements specific features. However, counteracting features like anonymity or the tracing of decisions are used. These features can be found additionally in publications that propose frameworks or design principles on how to design GCSS (Voigt and Bergener, 2013; Resnick et al., 2005). These principles counteract with the principles of collaboration, which is why new principles for CSS and new mechanisms for supporting collaborative creativity need to be developed. A major limitation of the systematic literature review is the defined set of keywords used to identify relevant literature as well as the restriction to scientific literature. With the set of keywords, results were limited solely to systems that explicitly aim to support creativity. Different terms for systems that are used to solve creativity-intensive problems were neglected, whereby relevant articles might have been missed out. For example, prior to the establishment of terms like CSS and CST, systems that support creative problem solving were often referred to as decision support systems (Proctor, 1993; Duncan and Paradice, 1992; Jessup et al., 1990). In addition, commercial systems and systems that appeared outside the scientific sphere could have been overlooked. A broader look on systems that involve collaboration and collective problem solving could furthermore reveal interesting results. For example, within social media, collaboration takes place and people work together to reach a common goal (Kaplan and Haenlein, 2010). This "joint and simultaneous creation of content" (Kaplan and Haenlein, 2010, p. 62), as seen on Wikipedia, involves collaboration principles like reciprocity (Xu and Li, 2015). In addition, with the help of social profiles that include personal information, users can connect with other users and get to know each other, which leads to the building of trust (Golbeck, 2009; Ziegler and Golbeck, 2007). However, successful collaboration within social media does not involve systematic creativity support, as the main goal of social media is different: connect people, enable self-presentation and support content sharing (Kaplan and Haenlein, 2010). Even though, social media allows collaboration, it often lacks major collaboration features, which collaboration technology addresses (Brown et al., 2010). Nonetheless, mechanisms from social media, like reciprocity, a common goal, social closeness and trust can be applied to CSS. However, currently, the potential of IT is not completely exhausted to actively support creativity and CSS are not designed to support collaborative creativity. This is in line with the comprehensive literature review by Gabriel et al. (2016). The review identified a lack of rich creativity support on the basis of advanced functionalities. Systems should adapt more to the needs of the users and provide cognitive stimulating content on its own. Gabriel et al. (2016) mentioned the use of Artificial Intelligence (AI) as a useful technology to achieve this. Even though the research community produced valuable feedback for the support of creativity using IT, companies need to adopt these approaches and explicitly need to implement CSS into their business. The following section provides insights about the management of innovation and the IT-supported creativity of companies to state the relevance of practice.

3.4 IT-Supported Creativity in Companies

Examining whether companies successfully implement CSS is complex and requires insights into the company's processes. Even though, some research report case studies of the use of CSS (Gabriel et al., 2016; Voigt et al., 2013a), further up-to-date information on the use of CSS in organization is needed to depict the relevance of IT-supported collaborative creativity for practice. For this purpose, this section looks at five theses that were supervised by the author between 2013 and 2017. All theses are done in cooperation with organizations and cover topics like innovation management, idea management and creativity support. All theses include a review of the current state of the usage of IS to support innovation, idea generation or explicitly creativity. The following theses are briefly analyzed considering their usage of active support and collaboration principles:

Design and development of an IT-supported concept to operationalize the front-end of innovation at a German SM (by Anonymized author, 2017 with Anonymized GmbH)

Anonymized GmbH is a medium sized company from anonymized that produces and sells dental products. In this thesis, the current state of the innovation management process was anaylzed and a practice-oriented concept for the management of the front-end of the innovation process was developed. The current process consists of a committee (the company's management) that receives and reviews all ideas that employees can communicate (verbally, physical note or via email). At the moment, anonymized has not established any measures aimed at encouraging employee initiatives. Both, the existence of ideas and the skills needed for initiatives are considered to be a given and not supported or encouraged in any way. A communication occasion to express the ideas is also not given. The use of IT for this process is limited to e-mails, which does not possess any appropriate creativity supporting or idea management functionality.

Crowdfunding on a Corporate Level - Possible options for the application of an internal crowdfunding platform in a large industry firm (by Anonymized author, 2016 with Anonymized AG)

Anonymized AG is a company that develops, produces and sells aircrafts. In this thesis, the current state of the internal idea management was analyzed and a concept for a crowdfunding on a corporate level to further develop the generated ideas into prototypes was established. The current state of the innovation management involved an IT system (HYVE Innovation management) where users (employees) were able to propose ideas and work on them. Collaboration was limited to commenting and assessing an idea. The process did not support creativity nor did it support further collaboration.

Design and development of software to support the innovation process (by Anonymized author, 2015 with Anonymized AG)

The thesis was written in cooperation with the Anonymized AG with the department of innovation management. The innovation management department follows the Stage-Gate Model by Cooper (Cooper, 1990) and used a Microsoft Excel Sheet for the storage and development of ideas. No active creativity support or IT-supported collaboration was implemented within this process.

The Anonymized - NLS project: Potentials and problems in the integration of user experience into the software development process (by Anonymized author, 2015 with Anonymized AG)
In this thesis, the Anonymized IT innovation management and development was examined and a concept for a so-called Next Level Sourcing (NLS) was developed. The current process, the IT-PEP, was a non agile development process, that was implemented in many departments and used various software systems. Mainly Microsoft Excel, Microsoft Project and standard communication software (email) was used. This process does not support creativity nor does it consider specific collaboration principles.

Analysis and potential of IT innovation management in an internal corporate venture of Anonymized AG (by Anonymized author, 2015 with Anonymized AG)
The motivation for this thesis was to overcome the slow capability of the IT innovation management of Anonymized AG. The process was not agile and had many involved stakeholder, which made the overall IT innovation management slow and ineffective. No explicit software was used to support this process, especially not to support creativity or to enhance collaboration.

The analyzed theses show, that innovation management within companies, even though innovation is considered as an important aspect, neglects creativity and the IT support of creativity. These brief insights into business processes also reflect the findings of scientific literature, which emphasize the necessity of creativity, creative employees and creativity support for the development of innovations. However, the specific implementation of innovation management lacks distinct support of creativity (Flynn et al., 2003; Franco and D'Angelo, 2011; Amabile and Pratt, 2016). Particularly when using IT, companies limit themselves to purely processing systems or idea management tools that do not endorse active creativity support. Nevertheless, companies today already attach great importance to a fruitful corporate culture, which allows their employees to work creatively and collaboratively (Amabile et al., 1996; Amabile and Pratt, 2016). However, the implementation is limited to the analogous corporate environment (Vandenbosch et al., 2006). In addition, the systematic literature review revealed that both, active IT-support and the adherence of collaboration principles in CSS is rare. CSS are mainly used to organize and manage ideas where collaboration is limited to tools that support communication and document sharing. The role of the IT is thus limited to an organizing or partially supporting degree and neglects the fact, that IT can also act as a producer of beneficial content. Therefore, the need for active IT support and rigor collaboration within CSS is important and has to be assessed.

4 Objectives and Research Methodology

The identified research gap and the analyzed innovation processes lead to one fundamental research question with two focal aspects: **How should information systems be designed, to make use of active IT and to support collaborative creativity?**
Examining this research endeavour, two main objectives and one approach can be identified. The use of active IT, as defined previously, can substantially enhance the creative process of an individual or a group and can thus lead to an overall better idea. In nowadays business, the sole support of managing and organizing ideas is implemented within companies and the full potential of IT is not exhausted, yet. Using novel algorithms and data to actively expand the solution space of individuals can lead to possible new solutions to existing problems. Thus, one objective of this research is to make use of active IT to support creativity. Most innovation processes are based on collaboration that bring synergetic effects and enhance collective performance further than the sole sum of individual performance. Most CSS however, focus on group effects and how to avoid negative cognitive and social effects with specific features that do not align with the principles of collaboration. Supporting the synergetic approach of collaborative creativity requires different mechanisms than current GCSS provide. The second objective of this research is to identify mechanism and propose guidelines for CSS that support collaborative creativity. The stated research question discloses an approach that involves the design of an artifact that should or can tackle the two mentioned objectives. The research question therefore leads to the research paradigm, which is a design-oriented approach (Vaishnavi and Kuechler, 2015).

4.1 Design Science Research Paradigm

IS are used to support organizational processes and improve their overall efficiency (Vaishnavi and Kuechler, 2015). IS involve humans and artifacts to the same extent and represent a coherent ecosystem where IT supports processes, involving groups, teams and individuals. In the research discipline of IS, two fundamental paradigms, behavioural science and design science are merged (Hevner et al., 2004). The origins of behavioral science can be found in the natural sciences. The study of behavioral patterns leads to the development of new theories that can be used as a basis for the implementation of IS to efficiently and effectively support entrepreneurial, organizational and individual processes. The developed theories consequently impact design decisions that are made when designing and implementing IS (Hevner et al., 2004). Design-oriented research has its origin in the engineering field, where artifacts are designed to solve specific problems (Vaishnavi and Kuechler, 2015). It is a practical approach that seeks to create innovative solutions for existing problems. Design and development is not based on behavioural theories but on the creativity and capabilities of the designer (Markus et al., 2002). It is often argued that on the one hand, behavioural science is not applicable for practice and that an explanatory approach does not sufficiently contribute to solve existing problems. On the other hand, traditional design-oriented approaches do not take existing theories into account that are inevitable for the solution or do not significantly contribute to research (Peffers et al., 2007; Hevner et al., 2004). Design Science Research (DSR) in IS however combines both paradigms and adds rigor and theory into the design of artifacts (Hevner et al., 2004). Within DSR, the developed artifact is considered to be the main contribution. However, in contrast to the design-based research practice in the engineering fields, it is based on a rigor problem evaluation, on possible theories that contribute to the development and on a comprehensive evaluation and demonstration of the developed artifact. DSR in IS has received attention due to the publication of Hevner et al. in 2004 and has ever since gained acceptance in the research community. With their framework, Hevner et al. combine characteristics of behavioural science and design science and propose "clear guidelines for understanding, executing, and evaluating the research" (Hevner et al., 2004, p. 75). In contrast to other research paradigms, which aim to describe and explain the existing world, Design Science Research shapes the world with the development of artifacts (Vaishnavi and Kuechler, 2015). The framework by Hevner et al. (2004) is derived in detail from existing development approaches in the field of IS, in which a great deal of work flows into the development of solutions that are intended to solve organizational problems. The DSR framework by Hevner et al. (2004) consists of three levels: environment, IS research and knowledge base, which are linked by the three cycles relevance, construction and rigor. It is designed to ensure that artifacts are designed (construction) based on business needs and requirements (relevance) and are build on applicable knowledge from theories, frameworks and methods (rigor) (Hevner et al., 2004). Figure 4.1 presents the DSR framework by Hevner et al. (2004). Additionally, the design activity is considered in two ways: as a product and as a process. The artifact that is the result of an activity and the process that leads to the artifact. In practice, this process is iterative and usually consists of the steps build and evaluate. The development starts with the identified problem and is shaped by the capabilities, creativity and capacity of the designer. By adding behavioral science practices, the design will now be expanded to include established theories and recognized phenomena. Thus, DSR in IS combines the utility of design research with the truth assumption of behavioral science. The framework proposed by Hevner et al. (2004) aims to insure a rigor application of the DSR paradigm, by pointing out the importance of a proper relevance identification and systematic evaluation. Furthermore, the authors advise to make a clear research contribution and communicate the contribution. Based on this framework, Peffers

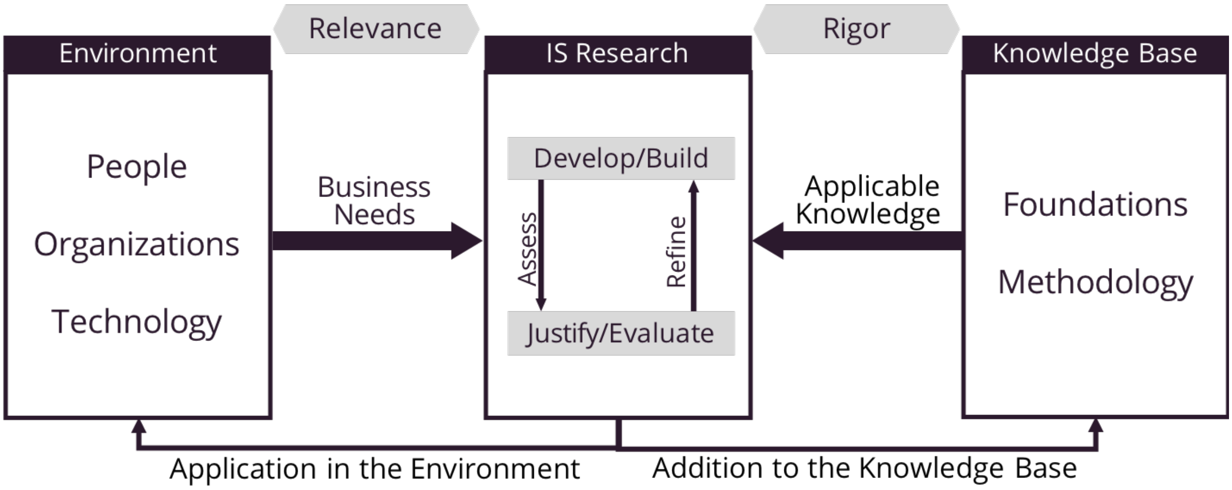

Figure 4.1: Information Systems Framework by Hevner et al. (2004)

et al. (2007) further developed a nominal process model for conducting DSR in IS, by analyzing four case studies using the DSR paradigm. The process model aims to incorporate a systematic procedure, principles and practices to carry out a consistent DSR project. With this systematic procedure, the recognition and legitimization of DSR should be enhanced and it should help researchers conducting and presenting DSR. This systematic approach of the DSR paradigm is called Design Science Research Methodology and consists of six activities, that can be seen in figure 4.2. This nominal process model has a sequential order, which however does not

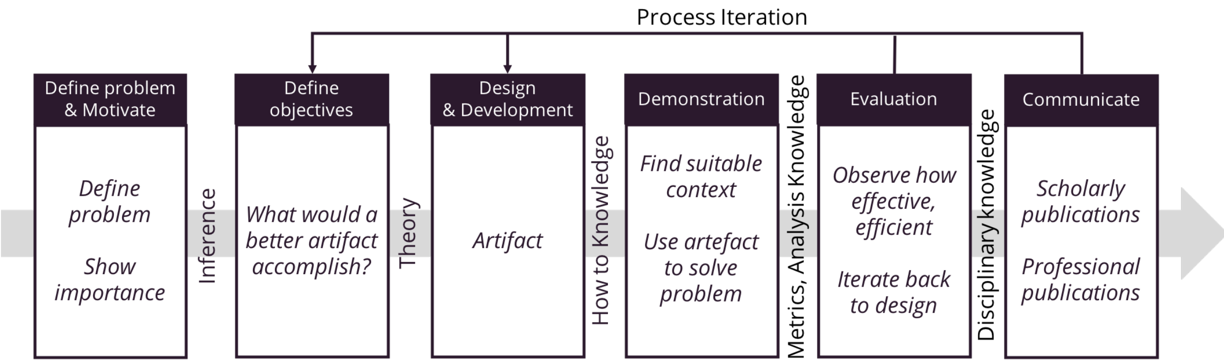

Figure 4.2: DSRM Process Model by Peffers et al. (2007)

necessarily need to be proceeded in this way. The process allows for different entry points and multiple iterations. Peffers et al. (2007) emphasize on different entry points depending on whether the researchers chose a problem-centered or a objective-centered point. However, both approaches focus on the development of an artifact and the demonstration and evaluation of its utility. This evaluation can be done in different ways according to Peffers et al. (2007) and Hevner et al. (2004). The analyzed case studies by Peffers et al. (2007) vary between a proof-of-concept, thorough testing processes or expert interviews. Hevner et al. (2004) argue that other qualitative or quantitative research methodologies, like controlled experiments need to be used to justify the utility of the artifact and substantially make a research contribution.

Therefore, the DSR paradigm or the DSRM should rather be seen as a paradigm involving various other research methodologies than a solely own methodology. Gregor and Hevner (2013) continue to use the term paradigm in their 2013 MIS Quarterly article and again depict the different methodologies that demonstrate the validity, utility, quality and efficacy of the developed artifact to create a research contribution. However, the main focus of this paper is to highlight the role of the artifact in DSR and classify different forms of contributions that can arise with the design and evaluation of an artifact. The emphasis is set on a unique, radical and innovative way to solve existing problems. Research has to create artifacts that do not exist before or are not optimal for the solution of the problem. The contribution of the research endeavour is therefore the innovative artifact and its comprehensive evaluation, which Gregor and Hevner (2013) divide into three levels that can be seen in figure 4.3. These levels show

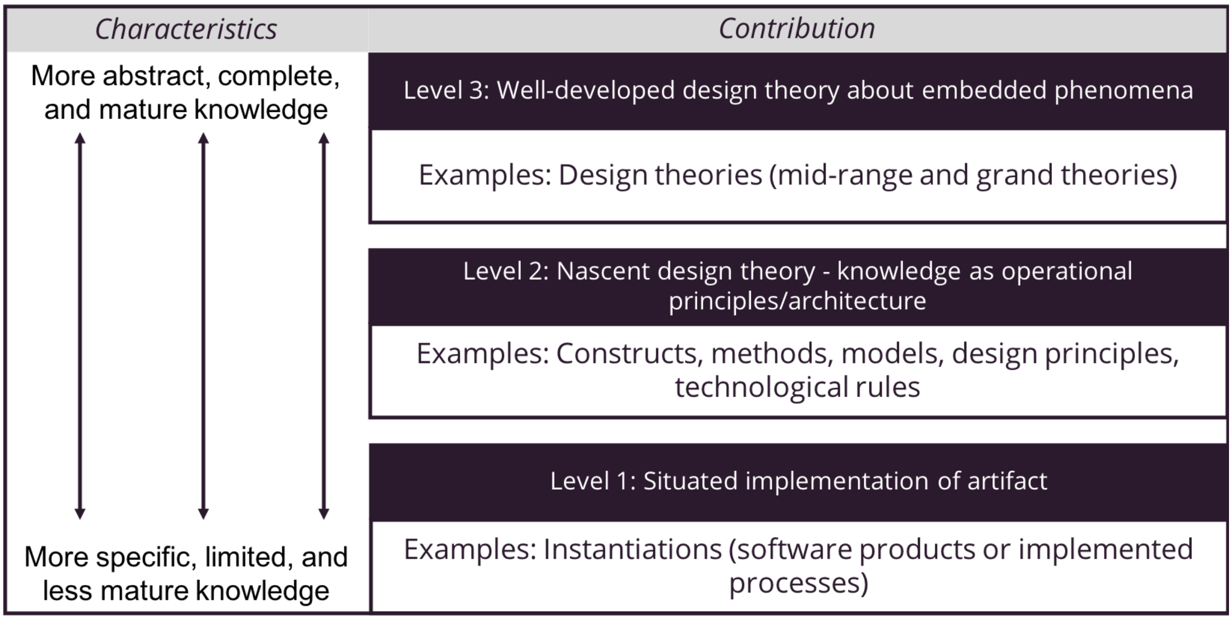

Figure 4.3: Design Science Research Artifact Contribution Types by Gregor and Hevner (2013)

that the contribution done by the DSR project consists of the developed prototype and the theories and principles resulting from its evaluation. However, the sole instantiation and its innovativeness, also accounts for a research contribution (level 1). The second level describes a nascent design theory and knowledge that consists of operational principles. This level represents evaluated artifacts or design principles that can be applied in other fields than the evaluated instantiation. Example artifacts for the second level are design principles, constructs, methods or technological rules. The most comprehensive level of artifact is the design theory with embedded phenomena. This third level contains arbitrary applicable theories and involves rigor evaluation and demonstration. Within the author's research endeavour, various artifacts of different levels were developed and evaluated. The focus was set on the innovativeness of the artifacts and its utility for each identified problem. The solutions range from instantiations to design guidelines and technological rules. The design and implementation was highly influenced by the author's own creativity and capabilities. Even though, the design was based on existing theories and was able to contribute to the research community, the question arises, whether the involvement of the researcher as an active participant can be considered as Action Research (AR).

4.2 Design Science Research, Theory-driven Design and Action Research

Researchers have raised the question, whether there is a distinctive difference between the DSR paradigm and AR. They argue that both paradigms share many similarities, like the involvement of the researcher who designs and develops the artifact in his/her own beliefs or the organizational context from where the problem occurs. The design as an artifact is considered as the researchers intervention as it "emerges from interaction with the organizational context“ (Sein et al., 2011, p. 40), is designed by the researchers' intent and is supposed to bring a desired change within the organization (Cole et al., 2005). AR is a change-oriented approach, where social processes can be studied by bringing change into these processes and by monitoring their effects (Baskerville et al., 2018). AR, introduced by Lewin in 1946, concentrates on practical problems and the involvement of the researchers in an organizational context, leading to social system change through their action. The measurement of the actions and the resulting change lead to new knowledge and subsequently brings scientific relevance (Baskerville and Myers, 2004). After the overwhelming success of DSR in IS, several researchers discussed the similarities between DSR and AR (Cole et al., 2005; Järvinen, 2007), leading to a MIS Quarterly publication by Sein et al. (2011) on Action Design Research (ADR), a research method that combines both paradigms. In contrast to the problem- and theory-oriented approach of DSR, ADR takes organizational and practical activities, cases and problems into account (Sein et al., 2011; Hevner et al., 2004). With an action oriented design approach, ADR addresses organizational problems to better understand the values, interests and assumptions of a company (Orlikowski and Iacono, 2001). The design of an artifact is collaborative, iterative and in close cooperation with companies. Sein et al. (2011) criticize the seperation of design and evaluation and the sequential process models in DSR (Peffers et al., 2007) and argue that a closer connection between these two aspects is necessary, which can be met with the researchers action. This interplay between design and use is important for a comprehensive ensemble artifact that is developed iteratively between the researcher and the organization. The ADR method proposed by Sein et al. (2011) adresses this within their four iterative stages, which can be seen in figure 4.4. These stages should insure an integrated view and a dynamic and iterative design of an ensemble artifact. Sein et al. (2011) define "ADR as a DR method that explicitly recognizes the emergence of artifacts at the intersection of IT and organization" (Sein et al., 2011, p. 52).

Another relevant research paradigm is Theory-driven Design (TDD), which in some aspects coincides with the DSR. TDD addresses the problem of unsystematic development of software

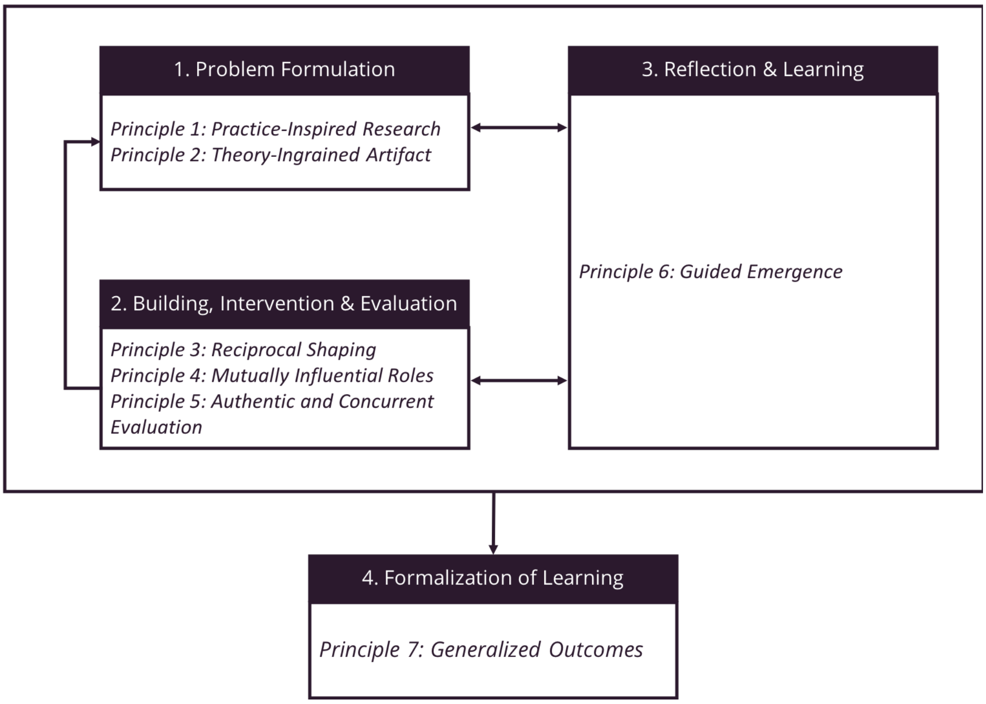

Figure 4.4: Action Design Research Method: Stages and Principles by Sein et al. (2011)

systems, without reference to concrete scientific theories (Card, 1989). Even though many successful developments have their origins in intuitive ideas, many of them fail because of the disregard of relevant theories. A rigorous theoretical approach to information system design can lead to non-intuitive design decisions that go beyond what is possible with an intuitive approach (Briggs, 2006; Card, 1989). TDD therefore focuses more on the theoretical foundations of the design of artifacts, than on explicit problems and innovative and novel solutions (Briggs, 2006). Thus, it can be said that TDD extends traditional design-oriented approaches to the inclusion of scientific theories. DSR, on the other hand, complements other aspects such as the problem of relevance, the innovative approach to solutions, and the rigorous evaluation and communication of the findings (Hevner et al., 2004).

In the next section, the author's research endeavour is discussed according to its applied research paradigm. In addition, the various research methodologies within the evaluation stages are depicted and discussed.

4.3 Research Approach

The initial approach and the procedure of the author's research was fundamentally DSR according to Hevner et al. (2004) and Peffers et al. (2007). Nevertheless, in this section, the four direct-embedded publications are examined for their overlap with the ADR paradigm. The publications are briefly analyzed according to their procedure and their degree of researcher intervention and organizational influence.

The article "Tracking Down the Negative Group Creativity Effects with the Help of an Artificial Intelligence-like Support System" describes a DSR approach with a level 1 artifact that was designed and developed based on the creativity and the capabilities of the researcher and on a theoretical foundation. The artifact was evaluated within an experiment. The contribution is a novel approach to solve an existing problem, the implemented prototype and the results of the experiment. The artifact was iteratively developed, previously published and discussed with experts (Steps 6 and 7 by Hevner et al. (2004)) on the International Conference on Design Science Research in Information Systems and Technology. The iterative development and mutual influencing roles (other researchers) have overlaps with the ADR paradigm. However, organizational influence during the development and evaluation was not present. Similar characteristics apply to the research on "A Creativity Support Tool for Cognitive Idea Stimulation in Entrepreneurial Activities". The level 1 artifact was designed and developed based on the creativity and capabilities of the researcher with specific requirements from an organizational context (entrepreneurs). The artifact is grounded on various theories and was evaluated within an experiment. The article "Anchored Discussion: Development of a Tool for Creativity in Online Collaboration" is a theory-driven design approach, where a level 1 artifact, that was mainly developed based on existing theories, was evaluated within an experiment. The researcher's intervention is low, as the artifact was completely build based on existing theories and without the goal to design an exceptional innovative artifact. The article "Forming Virtual Teams - Visualization with Digital Whiteboards to Increase Shared Understanding, Satisfaction and Perceived Effectiveness" presents the evaluation of an artifact, that was designed based on existing theories and a focus on the usage within a specific organizational setting (small and medium-sized companies). The artifact is a level 1 artifact, which was evaluated within an experiment. Even though, the evaluation was not conducted within an organization, the results are used within the DETHIS[1] project and are used by the cooperating companies and the platform that was developed within the project. The article "One for All and All for One - Towards A Framework for Collaboration Support Systems" propose design guidelines, that represent a level 2 artifact, which are derived from theories and existing studies and findings. The guidelines were developed in a deductive way from existing theories, studies and findings and provide a base for further research and evaluation. This process involved the researcher's intention and involvement, which represents characteristics from the ADR paradigm.

Overall, the main ADR charactertics in the researcher's work is the high intervention during the design and development phase. Most artifacts were designed to address unsolved problems in a specially unique and innovative way, which required the researchers creativity and capabilities. Even though, the artifacts are based on established theories, the creativity and the capabilities mainly shape the artifact. However, the main paradigm of the author's research is DSR, as the main aspect of ADR, the direct organizational influence due to the integration of the

[1] DETHIS (Design Thinking for Industrial Services) is a research project funded by the Federal Ministry of Education and Research (BMBF)

researcher into the processes of the organization, is negligible. In addition, the artifacts were not integrated within any organization, as well as the evaluations that were not executed within an organizational setting.

5 Publications in Context

In order to approach the previously stated research objectives, this chapter will provide a contextual frame for every publication of the author. In DSR, it is important to conduct research in an agile and iterative manner (Peffers et al., 2007). This means, that research outcomes, regardless of whether they are specific research results, research in progress paper or prototypes, should be published and discussed regularly. Peffers et al. (2007) highlight the importance of communication and dissemination in order to further revise and refine your research. This process ensures a continuous enhancement and further development of the research.

The author's publications are roughly grouped into three categories, representing the main focus of each article. The first category is the general category, presenting articles that cover the importance of CSS and IT-supported creativity for business innovation. The second category covers articles that focus on active IT support and the third category focuses on collaboration in creativity intense processes. However, articles have overlapping topics that are covered, which will be discussed as well.

5.1 General

The first approach to highlight the relevance of creativity, is the article "Situation-oriented Ubiquitous Information System Innovation – Leveraging User Integration" (paper 24). The article shows, among other things, the importance of creativity for innovation. The main focus of this article however, is an approach to leverage ideas within certain situations using a context-aware IT system. The article "Design Guidelines for Context-Aware Creativity Support Systems" (paper 16) continues to cover the topic of creativity and context-awareness. The literature review reveals context factors that are important for idea generation and proposes guidelines on how to design context-aware creativity support systems. Both articles show that IT-supported creativity is a relevant topic and that the situation of the user and the context is a considerable aspect for idea generation.

The articles "Kreativität und Entrepreneurship – Die Rolle von Kreativiätsunterstützung in der Existenzgründung" (paper 22), "Creativity and Entrepreneurship – The Role of Creativity Support Systems for Start-Ups" (paper 17) and "The Benefits of Creativity Support Systems for Entrepreneurs: An Exploratory Study" (paper 12) examine the importance of IT-supported creativity for entrepreneurs. With an exploratory study, the benefits of creativity support and

IT-supported creativity are revealed and special characteristics of the innovation process of entrepreneurs are presented. The results are, that especially at the beginning of the idea generation stage, IT can be useful to shape the final business model of a start-up. Additionally, the results show that active IT can support the generation of more versatile ideas (paper 2).

Paper 14, paper 11, paper 10 and paper 6 cover the application of IT within Design Thinking (DT), an approach that is based on multi-disciplinary teams, collaboration and creativity to come up with innovative solutions. Within different studies, semi-virtual workshops and IT support during analog Design Thinking workshops was evaluated. The results show, that it is possible to some extent to digitize the Design Thinking process and that creativity and collaboration benefit from the usage of specific IS.

Within paper 19 and paper 9 the potential of automated personality mining to improve cooperation and team composition was examined. First results show, that automated personality mining can be used to identify specific creative abilities and thus help to improve team composition (paper 9). Furthermore, personality mining can also be used to overall improve cooperation (paper 19).

5.2 IT-Supported Creativity

A developed prototype called "Crowdeas" (paper 25) that was published at the International Conference On Design Science Research In Information Systems And Technology (DESRIST) used information retrieval techniques to mine social media content (Facebook, Twitter, Tumblr) in order to provide creativity stimuli and foster divergent thinking. After presenting and discussing the prototype at the conference, it was further improved, tested within an experiment and published once again in an extended version (paper 1). The results showed, that the idea generation benefited from the additional stimuli by the system resulting in better ideas. Both publications present a prototype that follows an active approach, where IT independently supports the user during idea generation. Another active approach and prototype was presented within the publication "Semi-Automated Questions as a Cognitive Stimulus in Idea Generation". The prototype that uses specific algorithms and data bases provides additional stimuli to support the user during idea generation. After presenting and discussion the prototype at the Hawaii International Conference on System Sciences (paper 21), the prototype was also improved and evaluated within an experiment. The results were published in the International Journal of Entrepreneurship and Small Business (paper 2). In this publication, the link between entrepreneurship and creativity support is presented. The focus is set on active IT support with additional stimuli, which support entrepreneurs during the first stages of their start-up. As entrepreneurs often rely on one idea that is developed into the main business model, creativity and especially creativity support is of immense importance. All three articles follow the first research objectives of using active IT to support creativity. The articles "brAInstorm: Intelligent Assistance in Group Idea Generation" (paper 13) and "Virtual Moderation Assistance - Creating Design Guidelines for Virtual Assistants Supporting Creative Workshop" (paper 7) present an outlook of what IT is capable of and how active IT support within idea generation can be applied in the future. The brAInstorm prototype uses artificial intelligence to support brainstorming sessions, which represents the highest form of IT-supported creativity (Lubart, 2005).

5.3 Collaborative Creativity Support

Paper 20 covers priming, a method to expose an individual or a group to a certain stimuli, to support collaborative creativity. An experiment showed, that a group can be positively primed prior to a creativity process, enhancing collaboration and creativity.

Paper 10 presents a prototype that uses synchronous features to collaboratively work on a service blueprint. The paper reports the result of a study on the acceptance of the prototype and its suitability to support collaboration. The results show, that synchronously working with the developed system is an effective way to collaborate in a creative way. With paper 8, an approach to support TEI was developed. The prototype presents a virtual reality, where users get to know each other by going through various methods in order to build TEI and overall group awareness.

The paper "Tracking Down the Negative Group Creativity Effects with the Help of an Artificial Intelligence-Like Support System" (paper 1) not only uses active IT support in form of an external stimuli based on social media content, but also tackles negative group creativity effects. The paper was iteratively developed and after presentation and discussion further developed. An experiment then showed, that additional stimuli that was provided in the form of comments by an artificial intelligence-like support system called "Alan" was able to further support idea generation. Furthermore the experiment examined whether negative social and cognitive effects, like evaluation apprehension, were experienced when interacting with the pseudo artificial intelligence. Thus, an AI, representing the highest form of active creativity support, can be part of a collaborative creativity process, where it acts as a partner without causing negative effects to other collaborators. The results show, that the participants did not experience any negative effects while working together with the artificial-like support system.

One important aspect for collaboration, in order to pursue a common goal, is the shared understanding and a so called Shared Mental Model (SMM) of a group. With paper 23, the author presents an approach to support the forming of a SMM by using anchored discussion. Anchored discussion means the division of a text into parts to focus on specific detailed topics of a comprehensive idea. This can be seen as a division of labour as used in cooperation scenarios. The results of an experiment show, that it was not possible to increase the SMM. In a follow-up article that is based on the same experiment (paper 3), qualitative findings, however showed, that the interaction was more structured and that groups that used anchored discussion were able to work more organized. However, this attempt shows that using anchored discussion is a form of division of labour and thus should be defined as cooperation, where members of a group split work and independently work on different parts of an idea.

After this approach, another form of IT system to support the generations of a SMM was evaluated. Using a digital whiteboard, where users can synchronously and visually work on a problem was used to support the building of a SMM. An experiment showed, that working on a single object, without the division of labour, on a digital whiteboard was able to better form a group by improving the shared understanding of a given problem. This is an important prerequisite for a successful collaborative creativity. The research was published on the Hawaii International Conference on System Sciences (paper 15) and a further developed and in detail examined approach was published at the International Conference on Information Systems (paper 4).

In order to conflate the above mentioned approaches, paper 18 and the extended version, published in the Journal Education and Information Technologies (paper 5), presents design guidelines for collaboration support systems. The article presents a literature review and a normative approach on how IT systems should be designed to support collaborative creativity and other collaboration processes that seek to creative value. The design guidelines are build on the principles of collaboration and combine successful approaches on how collaborative creativity, collaborative learning and collaborative problem solving can be supported in regard to the principles of collaboration.

5.4 Conclusion

The contextual framework provides an overview of the author's research and a classification of the research work according to the research questions and defined objectives. Figure 5.1 gives a detailed overview of the research publications of the author. The history of the publications shows the iterative approach according to the DSR approach, whereby different concepts and prototypes were further developed based on the input from the research community (Peffers et al., 2007). The different concepts and prototypes depict that, among other things, there are different possibilities to support creativity and that it depends mainly on the given task. Also the number of people involved, be it a single person or a group, contributes to the design decisions of the corresponding CSS. However, all approaches tackle both objectives in different ways and contribute to a better understanding of IT-supported collaborative creativity. The contributions of the studies are either of empirical nature (results of an experiment or a survey), of conceptual deductive nature (guidelines or design principles) or prototypical results with software implementations. In the following chapters, the five most relevant articles, that contribute most to the research objectives are included. These are:

Paper 1. Tracking Down the Negative Group Creativity Effects with the Help of an Artificial Intelligence-Like Support System

Paper 2. A Creativity Support Tool for Cognitive Idea Stimulation in Entrepreneurial Activities

Paper 3. Anchored Discussion: Development of a Tool for Creativity in Online Collaboration

Paper 4. Forming Virtual Teams – Visualization with Digital Whiteboards to Increase Shared Understanding, Satisfaction and Perceived Effectiveness

Paper 5. One for all and all for one - towards a framework for collaboration support systems

Figure 5.1: Publications in Context

6 Paper 1

Tracking Down the Negative Group Creativity Effects with the Help of an Artificial Intelligence-like Support System

Abstract

Creativity has been addressed in a variety of research studies, with interest focusing on both individual and group creativity. In our research, we outline current studies analyzing the negative effects, which can arise when working collectively. Based on the DSR paradigm, we developed an artifact, in order to prevent individuals from being negatively influenced by others. Our prototype implements an artificial intelligence-like system, which tries to act in a human manner and aims to support the user when he or she is working independently. In a field experiment, we evaluated the positive influence and negative effects, i.e. social loafing and free-riding phenomena, during the idea generation stage. The results show that no social loafing effects appear while interacting with our artificial intelligence support system. However, the benefits of a group process were still experienced by the participants.

6.1 Introduction and Motivation

Creativity is the source of innovation, which is inevitable for sustainable success of an organization and which determines the survival of an organization in a market (Fischer et al., 2005). Innovation is a constant process, which cannot be carried out only once and is therefore in continuous need of creative individuals and groups. In a competitive environment, creativity is highly questioned, which occasionally negatively affects the creative ability of individuals and groups (Amabile et al., 1996). Supporting creativity can enhance the individual or the group (Tiwana and Mclean, 2003). Specific group techniques for creativity support, such as brainstorming, can provide further benefits and also enable generated ideas to be evaluated (Nijstad and Stroebe, 2006). Brainstorming, as proposed by Osborn (1957), consists of different principles designed to foster the process of idea generation (Osborn, 1953). During the stage of idea generation, all members of a group are asked to contribute by suggesting ideas, without being judged by other members and without self-criticism, with the aim being to collect a large quantity of ideas.

This should stimulate the idea generation and increase overall creativity (Osborn, 1953). The convergent process of combining and improving generated ideas will then enable the evaluation of good approaches and forming of a singular, superior idea. Although Osborn (1953) claims that brainstorming is a more effective way of supporting creativity and the generation of ideas, this technique has been questioned in recent research (Mullen et al., 1991; Stroebe and Diehl, 1994). Indeed, group creativity techniques, such as group brainstorming, can also result in productivity loss and production blocking in terms of individual creativity. In addition to different social processes, cognitive processes also appear in group creativity (Dugosh and Paulus, 2005). Individuals can be influenced simply by the presence of others with the size of the group affecting the degree of influence (Dennis and Williams, 2003; Gallupe et al., 1992). In our research, we focus on the productivity loss caused by social processes, such as production blocking, that occur during group creativity. Production blocking means that in a group only one individual can speak at the same time (Diehl and Stroebe, 1991). Various production blocking symptoms occur in real groups, which do not occur in nominal groups (Fern, 1982). Asking members to contribute as many ideas as possible, without being self-critical and without being criticized by others, cannot eliminate the fear of negative evaluation (evaluation apprehension) (Diehl and Stroebe, 1991). Group members might even consider their ideas as less important to the final outcome and would therefore hold back their ideas (free-riding) (Kerr, 1983; Kerr and Bruun, 1982). Groups tend to rely on their similarities, not on individual strengths and knowledge. This can result in individuals' creativity being suppressed, as they try to match the group's opinion to maintain unity (Jackson and Williams, 1985). Although group brainstorming should not have any hierarchical order (Osborn, 1953), different participants with different precedence affect group creativity. This ties in with the theory of social loafing identified by Karau and Williams (1993), which explains the tendency of individuals to expend less effort when working in a group than working individually. The presence of others influences the individual in his or her idea generation stage, up to and including a possible production blocking effect (Karau and Williams, 1997; Diehl and Stroebe, 1991). Even though nominal groups can address and amend productivity blocking effects, different negative phenomena still exist (Diehl and Stroebe, 1991). In addition to these effects, group techniques consist of a variety of advantages, e.g. a larger knowledge base, a variety of experiences, which support creativity in terms of idea evaluation, idea combination, mutual stimulation and idea improvement (Voigt and Bergener, 2013). Approaches on community driven idea and innovation management use this wisdom of the crowd to produce more and improved ideas (Yu and Nickerson, 2011). The strength of the crowd is immense and should be used especially in innovation management where different ideas are evaluated in terms of their capability, feasibility and practicability (Sawhney et al., 2005; Wuchty et al., 2007). Table 6.1 shows the positive and negative effects of group creativity techniques.

Positive effects	**Negative effects**
Stimulate idea generation (Osborn, 1953; Voigt and Bergener, 2013)	Social loafing (Karau and Williams, 1997) and free-riding (Kerr and Bruun, 1982)
Evaluation support (combined and improved ideas) (Osborn, 1953; Voigt and Bergener, 2013; Sawhney et al., 2005)	Evaluation apprehension (Diehl and Stroebe, 1991)
Idea quantity (Osborn, 1953)	Production blocking (Diehl and Stroebe, 1991)

Table 6.1: Benefits and Negative Effects of Group Creativity Techniques

Karau and Williams (1993) disclose in their paper several theories outlining the effect of social loafing. In particular they write about the lack of motivation and the realization that individuals exert less effort when working collectively. In our research, we concentrate on the effects of "dispensability of effort" or "free-riding" (Kerr, 1983; Kerr and Bruun, 1982; Karau and Williams, 1997) and the integrated model of individual effort on collective tasks (CEM). CEM "suggests that individuals will be willing to exert effort on a collective task only to the degree that they expect their efforts to be instrumental in obtaining valued outcomes" (Karau and Williams, 1997, p. 684). In our approach, we try to avoid these negative group effects by using different information technology techniques in order to build an artificial intelligence-like system that supports the individual in the idea generation stage. In the course of our DSR approach, we designed an innovative artifact that includes the functionality of idea generation, idea management and user interaction. This web-based prototype allows users to write and work on ideas in a community. A prior version of the prototype has been presented at the DESRIST 2014 conference and revised after the feedback of leading researchers. The main focus of this research was to support the idea generator during the divergent thinking stage. The goal was to stimulate cognitive processes by giving related, relevant, inspiring and supporting content to the idea generator (Siemon and Robra-Bissantz, 2014). However, in this paper we focus on social processes taking place during the interaction with an AI-like system.

6.2 Artificial Intelligence in Creativity Support

Artificial intelligence (AI) describes systems, software and machines that try to achieve human-like intelligence in order to take action in solving problems or supporting individuals (Pomerol, 1997; Salton and McGill, 1983). Research about AI in creativity processes is rare. In 1998, Boden published an article about creativity and AI that shows to what extent an AI system can fulfill the depth of a creativity process. This includes the exploratory functionality of generating new content and the evaluation and improvement of ideas. The conclusion shows that creativity is a complex process, which cannot be done completely by an AI (Boden, 1998). In our research we focus on the interaction with an AI. To support creativity, the system has to provide human-like support, contribute to ideas and even validate ideas. However, in trying to be supportive like a human, the stated negative group effects may not occur. As such, we hypothesize that an AI can provide the extra benefits of group creativity techniques without influencing the idea generator negatively. The development of an AI is highly specialized. Current research divides into different fields of study, which all have to be considered (Siemon and Robra-Bissantz, 2014). One of these fields is the knowledge of an AI that is based on its data sources. Reasonable data sources are difficult to determine, as these depend on the manner of ideas being generated. An idea generation process often has a specific topic and aims to produce a certain kind of idea. Thus, all ideas can be categorized before the support measures are carried out and specific data sources can be determined. Databases shouldn't rely on topic restrictions as supporting content can also be found in unrelated information sources (Voigt and Bergener, 2013). Another aspect of AI is the ability to learn, plan and reason during the whole supporting stage (Siemon and Robra-Bissantz, 2014). A learning AI ensures a closer interaction with the idea generator and can better react to the input by the individual. A better learning process results in improved planning and reasoning by the AI, which enables the AI to better know when and how to support the idea generator. If capable of reasoning, the AI also becomes capable of making decisions, which is named as one of the main aspects of human beings. Choosing between various alternatives is a complex human behavior and therefore difficult to adopt and integrate into an AI. The basic requirement for this to work is an effective communication between the individual and the AI, which is defined as Natural Language Processing (NLP). NLP tries to enable computers to understand and process human language input (Siemon and Robra-Bissantz, 2014; Porter, 1980). The developed prototype implements an artificial intelligence-like system, including the abilities of natural language processing, learning and reasoning. The following chapter explains the functionality and our implementation of the AI fields in detail.

6.3 Web-based Artifact

Developing and designing artificial intelligence-like systems is complex and comes with the fact that the intelligence of the artifact is only as intelligent as its designer (Pomerol, 1997). Reasoning, language processing and decision-making algorithms are the representation of the designer's view and therefore contradict the philosophical opinion, that decision-making and reasoning are different to each human being. As such, developing AI systems means not trying to mimic mankind in general, but imitating one defined person (Pomerol, 1997). Research about creativity support systems is widespread. Voigt and Bergener proposed an integrated framework for group creativity support systems, implementing a set of components and functionalities assessing social and cognitive group processes (Voigt and Bergener, 2013). Resnick et al. propose additional design principles for tools to support creative thinking (Resnick et al., 2005). Both publications consider social processes such as social loafing and production blocking, and propose methods to reduce these negative effects. Functionalities such as commenting and direct messaging are proposed to increase cognitive stimulation and the improvement of individual ideas. However, automation in creativity support systems is rare. An attempt of Ford implements information retrieval techniques to stimulate cognitive processes such as divergent thinking (Ford, 1999). Kules uses search engines to help find inspiring material and special databases to build associations in order to extend the idea generator's cognition (Kules, 2005). Our developed creativity support system implements various functionalities based on the proposed design principles and it includes information retrieval techniques to offer inspiring and supporting content to the idea generator. The web-based prototype has the capability of capturing (see figure 6.1), managing and supporting ideas in a community environment, which enables users to write and manage their ideas to get feedback from other users. The community can comment and rate the ideas, and thus improve and foster the thoughts of the idea generators. The following screenshot shows the start view of the idea generation tool, where all ideas of the community can be seen.

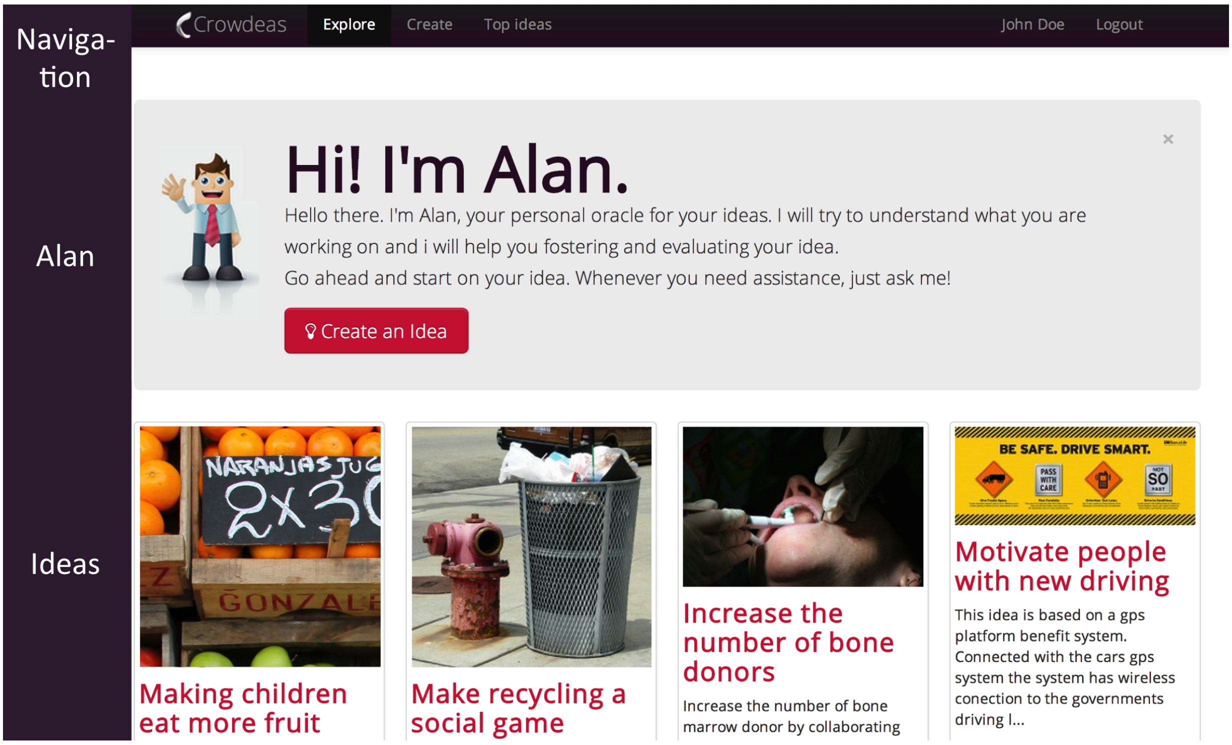

Figure 6.1: Start View of the Idea Generation Tool

As the boundaries between support systems and AI systems are loose, we implemented various aspects to turn the system into a more artificial intelligence-like system by personifying it (Dehn and Van Mulken, 2000). We gave the system the name "Alan" and the ability to talk to the user during the idea generating stage. Figure 6.1 shows the character design of Alan. The idea is hidden to the community until published by the user. This ensures that no negative group effects apply during the first creative stage, as no other user can see and comment on other ideas. In this stage, the AI-like system offers support. The system has the capability to understand written ideas by analyzing them with different algorithms. An information extraction algorithm, based upon the bag-of-words model, representing the idea in a pre-defined number of valued words, was integrated to represent the NLP functionality an AI should possess (see figure 6.2). This algorithm starts with a word count algorithm, splitting the text into single words and counting how often a word appears in the text. To filter the discriminative power of the words, a stop word removal algorithm removes all stop words based upon the "Full-Text Stopwords" list developed by MySQL for the English language[2]. As the word count algorithm cannot see the similarity between different lexemes e.g. plural and tense, a stemming algorithm was implemented. Stemming is the process of reducing words to their stem in order to group words of the same root. Stemming algorithms exist in diverse types and differ in terms of performance and accuracy. A commonly used algorithm proposed by Martin F. Porter in 1980 was used in our approach (Porter, 1980). The prototype uses a PHP encoding of the Porter Stemmer algorithm, implemented by Richard Heyes in 2005[3] and extended by us with a look-up algorithm. This look-up algorithm checks the stemmed words in a given table to ensure that the word is correctly stemmed. The look-up table used in this approach is the WordNet lexical database developed by Princeton University (Fellbaum, 2012). This combination ensures a more precise approach and extends the word stemming. The following figure shows the process of idea generation and the algorithms implemented in the AI.

After these steps, the text is represented by a finite list of words, where all words with the same root are seen as one term and the stop words are removed. The list is ordered according to the appearance of the word with a weightage relative to the number of all valued words (words without stop words). The outcome of this algorithm is a ranked list of valued terms, which represents the written idea. In a set of combinations, these valued terms will then be used to query several data sources (see figure 6.2). Finding creativity supporting content, which is not related to any specific topic depends on the type of database. In our approach we decided to use social media applications as our data sources. The popularity of social media applications is immense, which results in a large amount of data created by users all over the globe, not to mention a wide range of topics. Our approach queries the services Facebook, Twitter and Tumblr via the Application Programming Interface (API) and their Representational State Transfer (REST) architectural hypermedia data system. All queries aim for the main text or message written by the users, e.g. the tweets, messages and posts. The REST API's allow us to access the data of the services with different query term-combinations. To ensure a valued outcome, different algorithms and term-combinations are implemented in the system. All services are queried with the same term combinations, beginning with the five most valuable

[2] MySQL Full-Text Stopwords by Oracle Corperation, https://dev.mysql.com/doc/refman/5.7/ en/fulltext-stopwords.html, (assessed Jan. 04, 2014).

[3] The Porter Stemming Algorithm by Richard Heyes, https://tartarus.org/martin/ PorterStemmer/php.txt, (assessed Dec. 01, 2013).

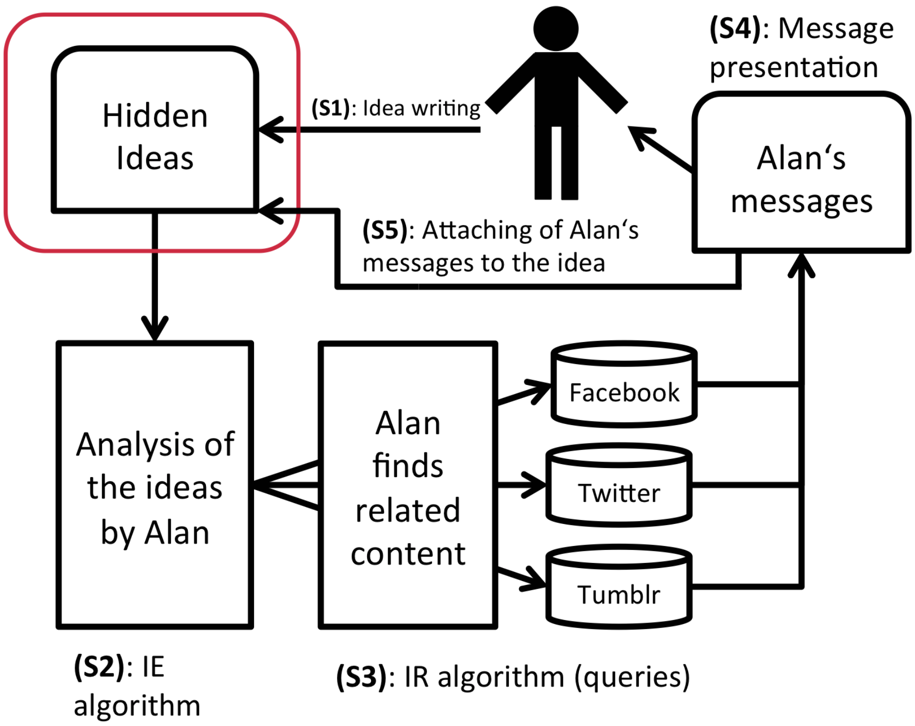

Figure 6.2: Idea Generation and Idea Support Process of the Prototype

words, followed by the four most valuable words and so on. To avoid duplicate query outcomes, a near-duplicate detection based on the Shingling-Jaccard algorithm was implemented (Broder, 2000). In the next step, the results are presented to the idea generator in a spiral shape ordered according to their relevance (see figure 6.3)). For the sorting of the results we use the vector space model, in which we first collect all of the words of a result and then calculate the according frequency vector. The same is done with the words of the idea. We then calculate the distances between the points (idea frequency vector to result frequency vector) and sort this conclusion in ascending order, i.e. shorter distances are better. This also ensures that the results, which are more closely related are visually closer to the idea. The following screenshot shows the presentation view with Alan's messages and the functionality used to mark and attach them to the idea.

The messages are written by users and are thus of human nature, which supports the way the AI tries to act and express itself as a human-like being. The social media messages found by the algorithm are presented to the idea generator as messages from Alan. By giving the system a name and the ability to directly interact with the user, we attempt to strengthen the sense of an AI (Dehn and Van Mulken, 2000). However, we did not attempt to design and implement a state-of-the-art AI in our research, we merely focus on the evaluation of the negative and positive effects in an artificial intelligence-like system. Hence, no evaluation was conducted to determine whether the system can be seen as an AI. The messages by Alan can be attached to the idea, and saved as an inspiration or a hint to improve the idea. Since the user is actively

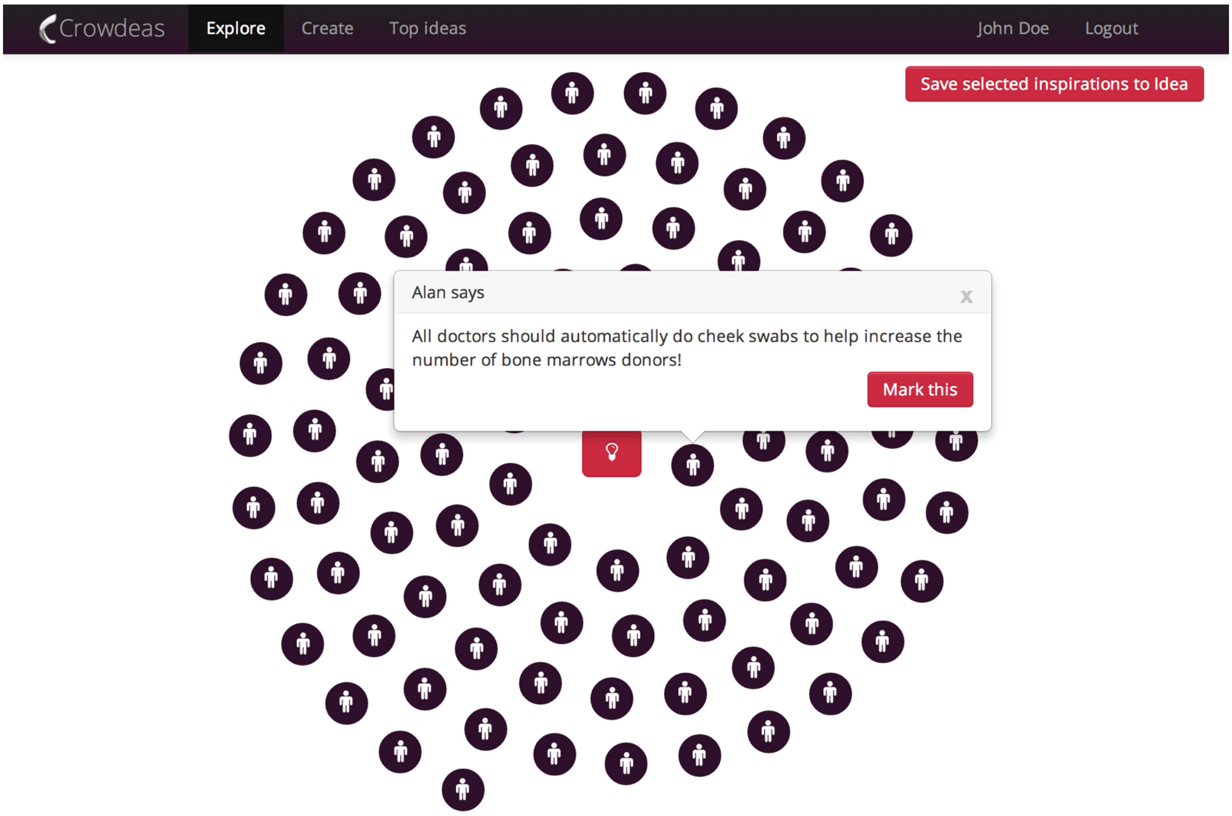

Figure 6.3: Presentation View of Alan's Messages

involved in this system and the requests are relatively short, we work with relevance feedback. We use the relevance feedback, when the user marks and saves a message from Alan to his or her idea, as our positive feedback to determine changes in the weights of the request (Salton and McGill, 1983). In this way, the attached messages are used and re-analyzed in conjunction with the initial idea. This implementation represents the interaction and learning ability of the AI-like system. Whenever a user marks content as important or related to the idea, the system adapts to the input and includes it into its analysis.

6.3.1 Evaluation of the Artifact

We aim to evaluate the utility of the artifact by a group of p=14 participants using the prototype to prove our main research question (Hevner et al., 2004). The focus of our research is to eliminate the negative phenomena, while still trying to achieve the benefits of a group creativity process. This main research question was divided into two hypotheses:

H1. The system can support a group creativity process by...
a. ... stimulating idea generation
b. ... evaluation support and idea improvement
H2. The system can avoid the negative group effects
a. ... free riding and dispensability of effort

b. ... and the outcome/effort relation (CEM)

We evaluated the prototype in a field experiment over a time period of four days, where the participants were asked to solve a specific task with the help of Alan. The participants were between the age of 21 and 33 and students (undergraduate, graduate and post-graduate) of different field of studies, including information technology, business economics and engineering. Five participants were female and nine were male. Various tasks were issued to the participants, who were then asked to choose one task. The defined tasks were of different topics to avoid any need for specialist knowledge. For example, tasks such as: "How can we make children eat more fruit and vegetables?" and "How can we establish better recycling habits?" After introducing the participants to the system, they worked over a period of four days in their familiar environment (at home or at work) on one idea with constant support by Alan. The participants started their idea from scratch and developed it over the period. During these days, Alan's assistance was used constantly. Log files of the system showed that the length of the ideas increased during the support. In addition to this, monitoring the use of Alan by means of the number of queries to Facebook, Twitter and Tumblr, showed that the help of the AI was intensive during all steps of idea generation. Furthermore, the number of messages marked and attached to the ideas (Ø=5 attached messages from Alan to an idea) showed that the user makes use of Alan's input. The idea generation stage was therefore highly influenced by Alan and can be seen as a collective work between the user and the AI-like system. After the completion of the experiment, the participants were asked several questions regarding the support of the AI and as to whether they experienced any negative effects from interacting with the system. Our two hypotheses were formed into five questions and were posed to the participants after the four-day period of idea generation. We used a self-report questionnaire with direct questions, based on the social processes causing productivity losses. This type of questionnaire ensures a better attribution to every social process and thus allows a precise assignment to the hypothesis (Paulhus and Vazire, 2007). For the answers to the questionnaires, we used the psychometric Likert-scale approach to ensure a wider range of possible answers (Likert, 1932). The following chapter presents the questions and the descriptive results of the experiment.

6.3.2 Results

For the validation of the first part of our hypothesis we asked the participants whether Alan was able to find content related to the user's idea (without explicitly asking for supporting content), whether he found new content which was unknown to the user, and if he was able to explicitly support the idea generation. The majority of the participants answered that they agree (p=7) and strongly agree (p=5) that Alan was able to find content, which is related to the idea. One participant neither agreed nor disagreed (neutral) on this question and one disagreed. Similar results emerged at the questions as to whether Alan was able to find new and unknown content. Three strongly agreed, seven agreed and three were neutral. One participant disagreed. Fewer participants agreed (p=2) or strongly agreed (p=6) that Alan was able to find explicit supporting content. Two participants disagreed on this question and four neither agreed nor disagreed (neutral). The following table shows the questions for the first part of our hypothesis, whether the artifact was able to achieve the benefits of a group creativity process. The answers strongly agree and agree are grouped (agree) as well as the answers strongly disagree and disagree (disagree).

Question	Answers (p total=14)
Did Alan offer content related to your idea?	Agree: 12 Neutral: 1 Disagree: 1
Did Alan offer new content, which was unknown to you?	Agree: 10 Neutral: 3 Disagree: 1
Did Alan offer supporting content?	Agree: 8 Neutral: 4 Disagree: 2

Table 6.2: Evaluation Results for Hypothesis 1

With a few exceptions, most participants experienced a supporting effect by using the prototype and found unknown content offered by Alan. Possible explanations for the participants who did not gain any benefits from Alan might be that a suggested idea was too specific or to short. This leads to fewer or even no query results from the services Twitter, Facebook and Tumblr. When evaluating the negative group effects, we asked the participants whether they exerted less effort for their idea because they knew that they were being supported during their creative stage (addressing free-riding and dispensability of effort) and whether they exerted less effort because the outcome might not only be their work. The majority answered that they strongly disagree (p=6) and disagree (p=7) that they exerted less effort due to knowing about the support. The same results were obtained from the second questions (CEM). Six participants strongly disagreed and eight participants disagreed that they exerted less effort, because they expect their effort not to be attributed to themselves alone. Table 6.3 shows the questions for the second hypothesis regarding the negative group effects:

Question	Answers (p total=14)
Did you exert less effort for your idea, because you knew that Alan was supporting you?	Agree: 0 Neutral: 1 Disagree: 13
Did you exert less effort on your idea, because your effort is not instrumental obtained to the outcome?	Agree: 0 Neutral: 0 Disagree: 14

Table 6.3: Evaluation Results for Hypothesis 2

The results show that no free-riding or dispensability of effort effects occurred during the use of the prototype and the interaction with Alan. Although, we did not evaluate the users' perception of Alan, the results show that an AI-like system does not affect the user in his or her creative stage in terms of free-riding or dispensability of effort.

6.4 Conclusion and Outlook

The contribution of this paper is twofold: First, we developed an innovative artifact with the functionality to generate, manage and work on ideas inside of a community. Multiple users are able to comment on and rate ideas, in order to help improve and validate them. The possibility of isolating ideas from the community whenever the user needs to work on unfinished thoughts means that it is possible to ensure that no negative group effects can influence the idea generator. However, hiding an idea from the community prevents other users from contributing their input to foster or improve the idea. As such, we implemented an AI-like support system that tries to act human-like, attempts to understands what the idea is about and tries to support the idea generator during the creative stage. No evaluation was carried out with regard to the users' perception of the AI-like system; however, we implemented algorithms and methods, which are widespread and commonly used in AI systems. Our focus was not on developing a state-of-the art AI, but rather on finding out about social processes when interacting with AI-like systems. As such, our main efforts were not invested in the development of the AI but fulfilling the basic principles of AI. The second contribution is the conducted experiment. The results show that the AI-like system was able to offer the idea generator new and unknown content and found information related to the idea. Furthermore, the majority of the participants said that the system was able to explicitly offer supporting content, which helped to improve or validate the idea. Despite this, the results for this question were not as significant as for the first questions. In can therefore be concluded that the AI needs to be improved in numerous fields. First of all, an improved NLP is required to insure a better understanding of the idea and an enhanced learning ability is needed to better interact with the user's actions. Furthermore, various decision-making abilities and a bigger knowledge base have to be implemented. A longer experiment duration could result in more supporting content, as the queried services are highly active and new content arises every second. Also the services do not incorporate content older than seven days into the query results. The experiment also showed that no free-riding and social loafing effects appeared while working with the AI-like system. Participants did not exert less effort on their ideas, because of the fact that an AI helped or influenced their ideas. In addition to this, the stated CEM had no effect on the participants. Even though this might be related to the users' perception of the system, it shows that there are no negative side effects in an idea generation process that is supported by an AI-like system. The conducted experiment and the implemented artifact presented in this paper are included in continuing research and will be further evaluated and improved. In particular, the small number of participants in our experiment hinders the generalizability of the results. An increased number of participants and a longer idea generation period could facilitate improved results. In addition to this, qualitative interviews could provide supplementary results to prove our hypotheses. The experiment will be extended to determine more group effects and supporting features of an AI-like system. In particular, the functionality of hiding an idea or working anonymously in a community will be evaluated. It can be noted that a variety of design principles for creativity support systems exist and automated creativity support can improve cognitive processes. However, the interaction with artificial intelligence in a creative stage is yet to be researched, especially in regard to social influence.

7 Paper 2

A Creativity Support System for Cognitive Idea Stimulation in Entrepreneurial Activities

Abstract

Entrepreneurship requires creative approaches to tackle many challenges faced in establishing a new business. A necessary precursor is the recognition and development of ideas in order to establish a beneficial business model. Recognizing opportunities and developing ideas requires entrepreneurs to be creative. Actively supporting the creative process can therefore result in enhanced ideas, leading to successful new products or services. Within this article, we discuss the relevance of creativity support and the use of information technology to support entrepreneurial creativity. As a part of the applied Design Science Research Methodology, we developed a Creativity Support System, which aims to support the divergent thinking process, which has been identified to be especially important for entrepreneurial ideation. We conducted an experiment to evaluate the efficiency of our artifact. The results indicate that the artifact, which automatically presents external word stimuli to the idea generator, is able to enhance creativity, expand the entrepreneur's solution space and supports the recognition of more idea aspects.

7.1 Introduction and Motivation

A continuous emergence of advanced technologies opens up various significant new business opportunities for entrepreneurs (Bridge and O'Neill, 2012). Entrepreneurs as well as established companies are faced with extensive challenges to resist international competition. The requirements to approach these opportunities increase (Kung and Schmid, 2015; Weerawardena and Mavondo, 2011) . The development of innovative business models demands entrepreneurs to generate valuable ideas that have the potential to become successful products or services. Since ideas represent the output of a creative process, being creative and supporting creativity becomes crucial for generating valuable business models. Creativity is therefore essential to develop a successful start-up (Amabile, 1988; Burkus, 2013) . Furthermore, characteristics and expertise of entrepreneurs can be compared to personality traits of individuals, who are distinguished as highly creative (Whiting, 1988). A study by Whiting (1988) identified comprehensive similarities between creativity-relevant characteristics and characteristics of entrepreneurs, whereas Ames and Runco (2005) specifically found a relation between divergent thinkers and successful entrepreneurs. Divergent thinkers are individuals who can produce a high number of unique ideas from a single starting point (e.g. a problem or a task) (Brophy, 2001). Further studies have shown that creativity is important for entrepreneurship and that creative thinking enhances entrepreneurial activities (Fillis, 2007; Fillis and Rentschler, 2005; Fillis and Rentschler, 2010; Ko and Butler, 2007). In order to build a successful company, entrepreneurs have to generate ideas for new products or services that are attractive for customers and have the potential to succeed on the market. Building profitable business models is based on the creation of novel and unique ideas, which marks a central aspect in entrepreneurship. This idea generation process can be regarded as the lifeblood of entrepreneurship (Ward, 2004), which points out the necessity of creativity for entrepreneurship (Zhou, 2008). Through creativity, valuable and even beneficial products and services, that lead to a competitive advantage, can be generated (Ames and Runco, 2005) . Enhancing creativity can therefore help to reach this competitive advantage. An idea is the outcome of a creative process that can be influenced. Influencing a creative process, consequently influences the creative outcome, which has led to a variety of creativity support techniques. These techniques attempt to improve the creative outcome by stimulating and manipulating the creative process (Mumford et al., 2012; Smith, 1998). Creativity support is often carried out in an environment where teams meet face-to-face and apply techniques like Brainstorming (Massetti, 1996). Due to increasing remote work, project teams are composed of employees who do not work in one place, but are globally dispersed (Gibson and Gibbs, 2006; Lurey and Raisinghani, 2001). This led to an extensive use of information technology to support creativity with computer-based systems (Massetti, 1996; Shneiderman, 2007). An early example is Electronic Brainstorming (EBS). Studies have shown, that EBS is able to additionally support creativity and even outperforms traditional Brainstorming sessions (Dennis et al., 1999; Dennis and Valacich, 1993; Gallupe et al., 1992). By now, a variety of computer-based systems that support creativity have been successfully implemented in companies and evaluated in research (Gallupe et al., 1992; MacCrimmon and Wagner, 1994; Massetti, 1996; Shneiderman, 2007; Valacich et al., 1994). However, the use of these systems in entrepreneurial activities and their benefits towards successful entrepreneurship are rarely examined. A study from 2016 by Siemon et al. shows the importance of Creativity Support System (CSS) for start-ups. In their exploratory study, they identified a lack of use of CSS in start-ups, which can aid the development of innovative ideas. In addition, they pointed out the importance of external influence that can benefit and enhance the idea of a start-up in an early stage (Siemon et al., 2016). This external influence is also referred to as the creative stimulus, which helps to form new associations (Santanen et al., 1999). The generation of ideas relies on the ability to combine existing knowledge and to build new associations, in order to produce novel ideas (Adamson, 1952; Duncker, 1945; Gick and Holyoak, 1980; Mednick, 1962). These stimuli aim to activate new solutions for individuals or groups, who are working on a creative task. In traditional face-to-face creativity sessions, a moderator or facilitator, who conducts a workshop, often provides this stimulus (Chiu and Shu, 2012; Fink et al., 2010; Gassmann and Zeschky, 2008; Knoll and Horton, 2011; Santanen et al., 2003). In virtual teams, automated idea stimulation can be used to facilitate the creative process. Implementing and adding an IT-system that automatically generates stimulating content to the creative process can enhance individual creativity by acting as an external stimulus (Boden, 1998; Boden, 2009; Ford, 1999) . In our research, we developed a computer-based system to enhance entrepreneurial creativity. The system automatically generates creativity stimulating content that aims to support divergent thinking, which has been identified as particularly important for entrepreneurs (Ames and Runco, 2005; Gielnik et al., 2012). Our objectives are to create a system that can be beneficial for the generation of the initial idea of a start-up and subsequently improve the overall creativity support in entrepreneurial activities. This can also be favorable for established companies that seek to expand their business by generating new ideas resulting in beneficial business models. However, we specifically focus on start-ups, where the support of divergent thinking is inevitable, in order to expand the solution space and recognize opportunities. For a better understanding, the theoretical foundations of creativity and creative stimuli are provided in the following section. Furthermore, the relation between creativity, creativity supporting information technology and entrepreneurship is stated. Following the Design Science Research Methodology (DSRM), we designed and implemented a web-based prototype to address the identified problems stated in the introduction and the theoretical background. In order to evaluate and demonstrate whether our developed prototype effectively addresses the defined objectives, we conducted an experiment (Peffers et al., 2007). Subsequently, the results of the experiment are discussed and implications for further research and practical use are given.

7.2 Theoretical Background

Advanced technologies and shorter product life cycles increase the necessity for innovations (Weerawardena and Mavondo, 2011; West et al., 2014). Schumpeter (1934) defined innovations as establishing new solutions, with which companies should leave the usual path of the economy. However, creative ideas cannot yet be described as innovations (Amabile, 1988; Walton, 2003). An idea transforms into an innovation when the idea leads to new products or services that are successfully established on the market (Cropley, 2016; Danneels, 2002). Transforming ideas into innovations involves various steps, from market research, prototyping, implementation and market entry and it requires capacities and financial resources (Bullinger, 2008; Kung and Schmid, 2015; Weerawardena and Mavondo, 2011). A systematic innovation management involves the support during the entire innovation process from the generation of new ideas to their implementation and market entry. A range of different stage models for the description of an innovation processes exist and involve the activities needed to move from an idea to an innovation (Cropley, 2016; Germonprez and Levy, 2015). According to these models, the stage of idea generation and evaluation is closely linked to creativity (Amabile, 1983; Amabile, 1988; Mayer, 1999). Therefore, creativity is a crucial factor for successful innovations and beneficial business models (Burkus, 2013).

7.2.1 Creativity

Even though the term creativity is widely used, it is not clearly defined (Parkhurst, 1999; Runco, 2004). Over many years, creativity has been discussed in various research fields such as psychology, philosophy, business and even computer science (Amabile, 1983; Csikszentmihalyi, 2013; Guilford, 1950; Massetti, 1996; Mumford et al., 2012; Osborn, 1953). Often, creativity refers to the ability of an individual or a group of individuals to produce ideas, which are novel, useful and appropriate (Amabile, 1983). Past research concentrated on individual creativity and what the qualities of inventive individuals are. Likewise, Amabile (1983) states that the creation of ideas is heuristic. This infers that a procedure is required to generate ideas. Rhodes (1961) mentioned this procedure as one of his four P's of creativity: person, process, product and press. He characterized the process as the communication, learning, and thinking during the generation of ideas. Other researchers describe the procedure of ideation as a recombination and change of existing information (Boden, 1996; Mednick, 1962). Furthermore, a model by Mumford et al. (2012) separates the creative process into eight stages: 1) problem definition, 2) information gathering, 3) information organization, 3) conceptual combination, 4) idea generation, 5) idea evaluation, 6) implementation 7) planning, and 8) solution monitoring. These eight stages can be classified into two sub-forms as indicated by the cognitive capacity that is required: a convergent and a divergent process (Finke et al., 1996). These processes were initially characterized and documented by Guilford in 1950. He examined different individual qualities that contribute to creativity. Divergence refers to the ability of information gathering, the ability to form associations, perform mental leaps and to think out-of-the-box (Guilford, 1950). Convergent thinking is needed during idea organization, evaluation and selection (Briggs et al., 2003; Hilliges et al., 2007; Voigt and Bergener, 2013). Guilford depicts divergent thinking as the capacity to build up an assortment of unordinary and differing ideas. Convergent thinking is depicted as concentrating on the execution, and the assessment of individual ideas (Guilford, 1950; Hilliges et al., 2007; Voigt and Bergener, 2013). Aside from Guilford, other researchers examined the personality traits that classify a creative person and the interplay between divergent and convergent processes (Amabile, 1996; Benedek et al., 2013; Brophy, 2001; Hocevar, 1980; Ward, 1975). These processes are highly influential and depend on creative stimuli (Hilliges et al., 2007; Santanen et al., 1999), which is why creativity techniques are mainly used during idea generation. Creativity techniques are methods to encourage the creative capability of an individual or a group of individuals. Creativity techniques use social and cognitive systems to promote creative actions (Herring et al., 2009; VanGundy, 1992). To improve an idea, creativity techniques approach the idea generation process. Creativity techniques help to break away from rigid patterns and structures, try to form new associations, expand the solution space and present new opportunities (Csikszentmihalyi, 2013; Finke et al., 1996). By now, a variety of creativity techniques were presented in existing literature and are used in practice (Knoll et al., 2015; VanGundy, 2008). However, every technique follows a different concept and aims to support different thinking types. Choosing the right technique is therefore essential for an effective creative process. In entrepreneurial activities, it is important to recognize opportunities (DeTienne and Chandler, 2004) that can transform into beneficial business models. As a result, creativity techniques that specifically aim to support the divergent process and expand the solution space are appropriate. By doing so, the usage of this creativity techniques can potentially enhance the entrepreneurial creativity and thus lead to an improved idea. Whether an idea will develop into a successful innovation can only be judged when the idea evolves into a product or service and later succeeds on the market. However, for start-ups, which often rely on only one product or service at the beginning (Ward, 2004; Zhou, 2008), it is important to validate whether an idea has the potential to become a successful business model. Therefore it is indispensable to validate an idea from the beginning, before investing time and effort on its implementation. Validating ideas, which do not have certain performance indicators, is intensive and complex. Evaluating creativity can be separated into two sections; idea quantity and idea quality (Reinig et al., 2007; Reinig and Briggs, 2008; Shah et al., 2003; Wierenga and Bruggen, 1998). In spite of the fact that idea quantity is frequently utilized as a marker for creativity, it is regularly deficient and dismisses the significance of idea quality. Current research emphasizes examining idea quality with independent judges (Briggs and Reinig, 2007; Dean et al., 2006; Shah et al., 2003; Wierenga and Bruggen, 1998). In 2006, Dean et al. compiled a comprehensive literature review on how to assess ideas and subsequently on how to measure the effectiveness of a creative process. They composed four dimensions, with eight sub-dimensions to evaluate an idea. Even so, assessing idea quality cannot give exact predictions on the success of an idea on the market, it is important to exclude incomplete and disadvantageous ideas, which can cause the failure of a start-up. Therefore, it is necessary to systematically evaluate whether an idea can be judged as novel and if it has the potential to evolve into a successful product or service.

7.2.2 Creativity and Entrepreneurship

Studies have shown that entrepreneurs tend to be more creative and are more likely to accomplish a creative problem solution (Al-Atabi and DeBoer, 2014; Neck et al., 2014; Shane, 2003). In addition, the personal experience in entrepreneurial activities influences the creativity of individuals. Entrepreneurs who have already founded more than two companies show a higher level of creativity (Ames and Runco, 2005; Gielnik, 2013). This relation between entrepreneurship and creativity can be defined as bilateral. The assumption that creativity has a positive effect on entrepreneurship is confirmed, as well as the assumption that entrepreneurship promotes creativity (Gielnik, 2013). More specifically, the positive effect of creativity on generating business models illustrates this influence (Gielnik et al., 2012). DeTienne and Chandler (2004) examined the influence of a training program in enhancing the level of creativity of university students. In their study, they identified, that by enhancing creativity through the training, the skills of students to identify business opportunities could be increased. The training aimed to improve the recognition of new opportunities and solutions and extended the existing knowledge base. The results disclose an increase of the identification of new business opportunities by the students who completed the training. In addition to that, training on divergent thinking, like forming associations, conceptual combining, analogous reasoning and out-of-the-box thinking, has been identified to promote entrepreneurial activities (Gielnik et al., 2012). Ames and Runco (2005) also support this statement, as they identified that divergent thinking enhances the generation of business models. However, Gielnik et al. (2012) point out to the interplay between divergent and convergent thinking and state that both processes are needed for the creation of a comprehensive business idea. Further studies confirm the importance of a systematic innovation process and the beneficial impact of creativity techniques on entrepreneurship (Gielnik et al., 2012; Kirchgeorg et al., 2010).

7.2.3 Creativity Support Systems

Computer-based systems that provide, organize or process information during a idea generation process can be referred to as a CSS (Shneiderman, 2007; Massetti, 1996). The benefits of CSS are broad and companies highly profit from their usage, which points out to the importance of CSS in business activities (Cherry and Latulipe, 2014). Influencing and stimulating information is considered as especially relevant for a CSS. CSS can approach both individuals and groups and can thus be divided into two different categories; Individual Creativity Support Systems (ICSS) and Group Creativity Support Systems (GCSS). ICSS support individuals during a creative process, whereas GCSS help to combine the skills and knowledge of a group (Massetti, 1996). By synchronous communication, information sharing and idea comparison, creative stimuli are exposed to the idea generator. In ICSS, no cognitive or social stimulation by other individuals exists and the focus is set on the individual creative process and its enhancement (Massetti, 1996). However, specific ICSS that aim to support individuals can also be implemented into the context of a GCSS, where the overall group process is supported but specific features of the system support individual creativity. We focus on an ICSS that stimulates and influences the individual creative process, rather than supporting the organization and evaluation of ideas. Even though, our developed artifact can also be implemented within a GCSS. Examples for

ICSS are, among others, information visualization systems, development environments or manipulation systems (Shneiderman, 2007). These systems are based on passive support, where the user is not exposed to new stimulating content. They offer various mechanisms, instruments and tools to express creative thoughts, but do not actively support the individual to form new associations and recognize novel opportunities. Active creativity support means that a system provides supporting and stimulating information on its own (Besold et al., 2015; Herring et al., 2009; Kules, 2005). In our research we focus on this active form of creativity support and designed and implemented an artifact that approaches this. As mentioned before, information that influences the creative process, in order to enhance an idea, is defined as creative stimulus. In the following section, we clarify the nature of a creative stimulus and its role in creativity support.

7.2.4 Creative Stimulus

Anything that externally affects a system can be seen as a stimulus. A creative stimulus is therefore everything that has an impact on a creative process. Creative stimuli are often referred to as inspirations and have a long tradition in research (Csikszentmihalyi, 1997; Osborn, 1953; Rhodes, 1961). A creative process results in a creative outcome and the outcome differs when a creative process is exposed to a creative stimulus (Herring et al., 2009; Howard et al., 2010). The creative environment can be defined as the context, setting or situation the creative process takes place in. As such, everything external that affects the creative process is within the creative environment. This environment or "press", as Rhodes (1961) calls this environment, includes other individuals, who can influence the process by additional contributions or even by their presence alone (Duncan and Paradice, 1992; Forster and Brocco, 2008; Gallupe et al., 1992; Nunamaker et al., 1987). Apart from other individuals, objects and settings of the environment can enhance or impair creativity (Siemon and Robra-Bissantz, 2016). However, if the environment lacks creative stimuli, the individual's ability to form associations and perform mental leaps becomes crucial for creativity. Past research examined the creative mind and explored the characteristics needed to create novel ideas (Hocevar, 1980; Runco and Acar, 2012). Results show, that the ability to form associations and to perform mental leaps are related to creativity (Krampen, 1997; Runco and Acar, 2012; Ward, 1975) . In addition, aspects like training (Amabile, 1996; de Bono, 1994; VanGundy, 1992) and motivation (Amabile, 1996) can enhance creativity. The Cognitive Network Theory (CNT) attempts to explain why individuals neglect nearly 80ôf the solution space when dealing with complex problems (Santanen et al., 2000). The theory is grounded on the confinements of the human memory and explains that different associations (frames) are connected in a restrained cognitive network. These frames are based on individual experience and knowledge and can be activated by creative stimuli. However, conventional stimuli have the tendency to only activate common frames, which is the reason why novel stimuli ought to be utilized to trigger other frames and expand the solution space (Hender et al., 2002; Santanen et al., 2000). Creative stimuli can differ in their nature, depending on the underlying cognitive principle and the general type. Knoll and Horton (2010) examined 101 creativity techniques with respect to their underlying cognitive principle and their ability to change the perspective of the idea generator. They discovered that merely three cognitive principles lead to a change of perspective, resulting in overall better ideas. These cognitive principles are analogy, provocation and randomization, whereas overall 54 of the 101 analyzed creativity techniques help to change the perspective. In our research, we focus on the stimuli type and the underlying principle random. A random stimulus exposes sporadic words, pictures or other generated content to an idea generator (Howard et al., 2010; Kosorukoff, 2001; MacCrimmon and Wagner, 1994; Ray and Myers, 1988). In our research we created such a stimulus in the form of randomized semi-automated questions. These stimuli are classified as word stimuli. The results of studies evaluating the effects of word stimuli on creativity indicate that related words, word combinations and lists of words can enhance creativity (MacCrimmon and Wagner, 1994; Massetti et al., 1999; Proctor, 1993). In our research we focus on word stimuli in the form of questions, which stimulate the idea generation by considering new and more diverse aspects.

7.3 Research Objectives

Deriving from the stated theories, we identified a strong relation between creativity and entrepreneurship and additionally disclosed the importance of active creativity support for entrepreneurial activities. We classified creativity support and specified the most appropriate form for entrepreneurial activities, which is creativity support that specifically supports the divergent process in order to expand the solution space. We defined creative stimuli and pointed out the role of external stimulating content for an active creativity support. Apart from the comprehensive research on creativity and entrepreneurship, examinations on the effect of active creativity support and especially computer-systems that support creative entrepreneurial activities, is lacking. In addition, the usage of CSS in entrepreneurship is limited, which can result in unused potential. Active creativity support and the use of CSS can thus bring sustainable benefits to entrepreneurs that seek to develop ideas and subsequently build successful business models. This active creativity support should be designed according to specifically support entrepreneurs. We identified that external stimulation with additional word stimuli could be effective and consequently argue to design and implement an innovative prototype that can fulfill these requirements. Our research question is, if a specifically designed and implemented artifact can effectively support individuals when generating ideas. The additional creative stimuli, provided by the artifact, are supposed to expand the solution space and support the idea generator to produce more versatile ideas that cover more aspects. Hence, we hypothesize (H1) that the ideas generated with the additional creative stimuli are more novel and more effective than those developed without the creative stimuli. Additionally, we hypothesize (H2) that the use of the web-based artifact enhances the diversity of an idea and the number of aspects that are considered.

7.4 Methodology

With our approach to generate new insights through the design, implementation and evaluation of an innovative artifact, we follow the DSRM (Gregor and Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). Peffers et al. (2007) constructed a framework and procedure for DSR in information systems, which we specifically followed in our research. The first step concerns problem identification and motivation, which we presented in section one and two. From the identified research gap and the theoretical background, we derived our objectives and defined our solution of designing an innovative artifact. Within this section we will describe our solution, a CSS that aims to enhance creativity for entrepreneurs. Furthermore, we will describe our conducted experiment, where we demonstrated the functionality and evaluated, whether our innovative artifact is an appropriate solution for the identified problem. For this purpose, we developed a post ideation survey to assess the functionality and effectiveness of the active creativity support. Additionally, we assessed the quality of the ideas that have been produced with the artifact.

7.4.1 Design and Implementation of the Artifact

Our web-based artifact is an ICSS, where users work individually on their ideas. The system does not support collaborative idea generation, nor does it include any unintended creative stimuli (e.g. shared ideas). This ensures no influence and stimuli by other group members or other presented content. However, other users can issue a problem or a task that ought to be dealt. Creating a task includes a textual description and a number of questions, which should be answered by the idea generators. This task serves as the starting point for the idea generator. It contains a current issue or problem, as entrepreneurial ideas often evolve from a problem, an issue, a desire for a product or an improvement (Siemon et al., 2016). The questions represent a main issue of the problem that has to be addressed by the idea generators. First, the system analyzes the original questions. This is done by tokenization and normalization of the question. Tokenization is the process of breaking a text up into single words, followed by a normalization process, which maps variants of these words to a single and standardized form. Additionally, stop words are removed in order to recognize valuable words. Stop words refer to the most common words in a language and are usually filtered out for natural language processing (e.g. she, at, is, which, on etc.). The system then proposes several alternative terms for the task creator to choose from. For the alternative terms, the lexical database WordNet 3.0 is used (Fellbaum, 2012). In WordNet, words (nouns) are hierarchically arranged according to their semantic features in synonym groups, denominated synsets. Synsets are sets of words from the same lexical category, including simplex words as well as collocations. The single synsets are linked according to conceptual-semantic and lexical relations (Fellbaum, 2012). For the word suggestions, the relations synonymy, hyperonymy and hyponymy between the synsets were used. Hyperonymy describes the compound of the type super ordination (X is the preamble of Y) and hyponymy describes a subsumption relation (X is a kind of Y) between the synsets. Then, words are suggested to the idea generator, which are arranged in WordNet at higher or deeper hierarchical levels and have one or more synsets related to the input word. From the set of selected words, the shuffle function creates new questions that can stimulate the idea generator to consider different and new aspects. Figure 1 shows a screenshot of the task generation, where a user selects the semi-automated question. After the user has provided the first question, it is necessary to also choose alternative terms for significant words within the question. The words marked in grey are automatically recognized as stop words and are regarded as insignificant so that no alternatives are generated for them. Other words that have not been identified as stop words are marked in green. When the system misjudges a word as not being a stop word, the user can manually mark it. Afterwards, the user can navigate through the automatically generated words and select them.

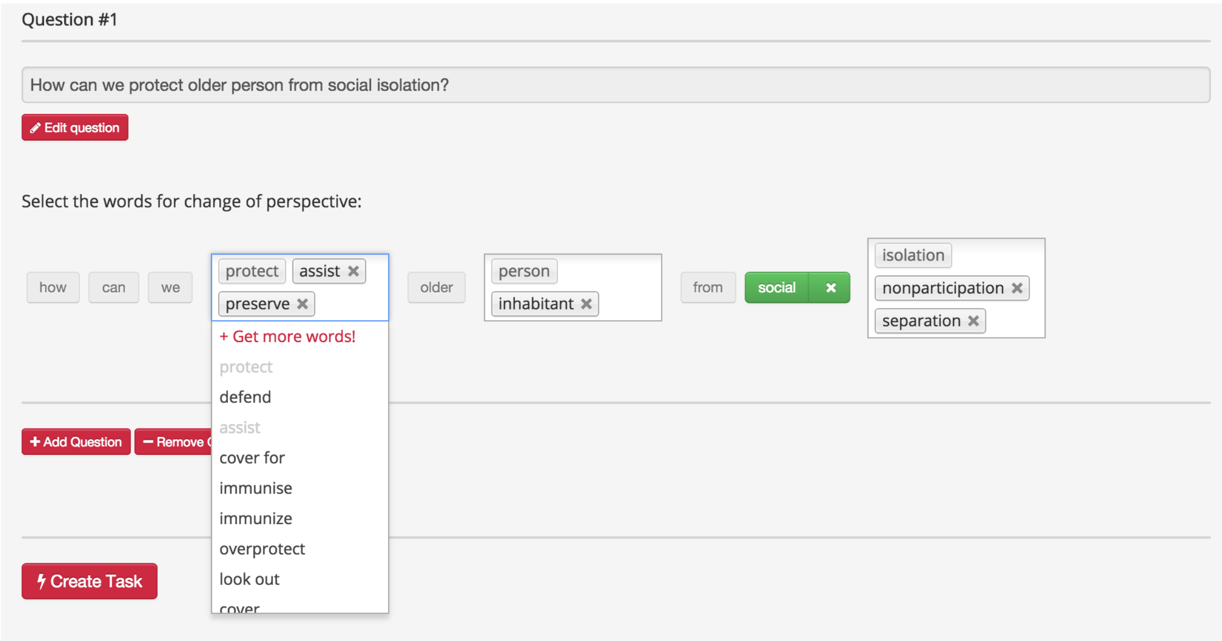

Figure 7.1: Generation of the Semi-automated Questions

Other users can then view all generated tasks to select one and compose an idea addressing the problem (see figure 7.2). The system provides a text editor with different formatting options, where the user can write an idea down. When creating an idea, the user refers to the task description and the main issues, stated in the original task. In addition, the user can randomly shuffle the questions. This is where the additional words, selected by the task generator, are used. The algorithm swaps the prior chosen significant words with alternatives and subsequently generates new questions. These questions are the creative stimuli that aim to help the user to form unknown associations. The idea editor, the questions and the shuffle function can be seen in figure 7.2.

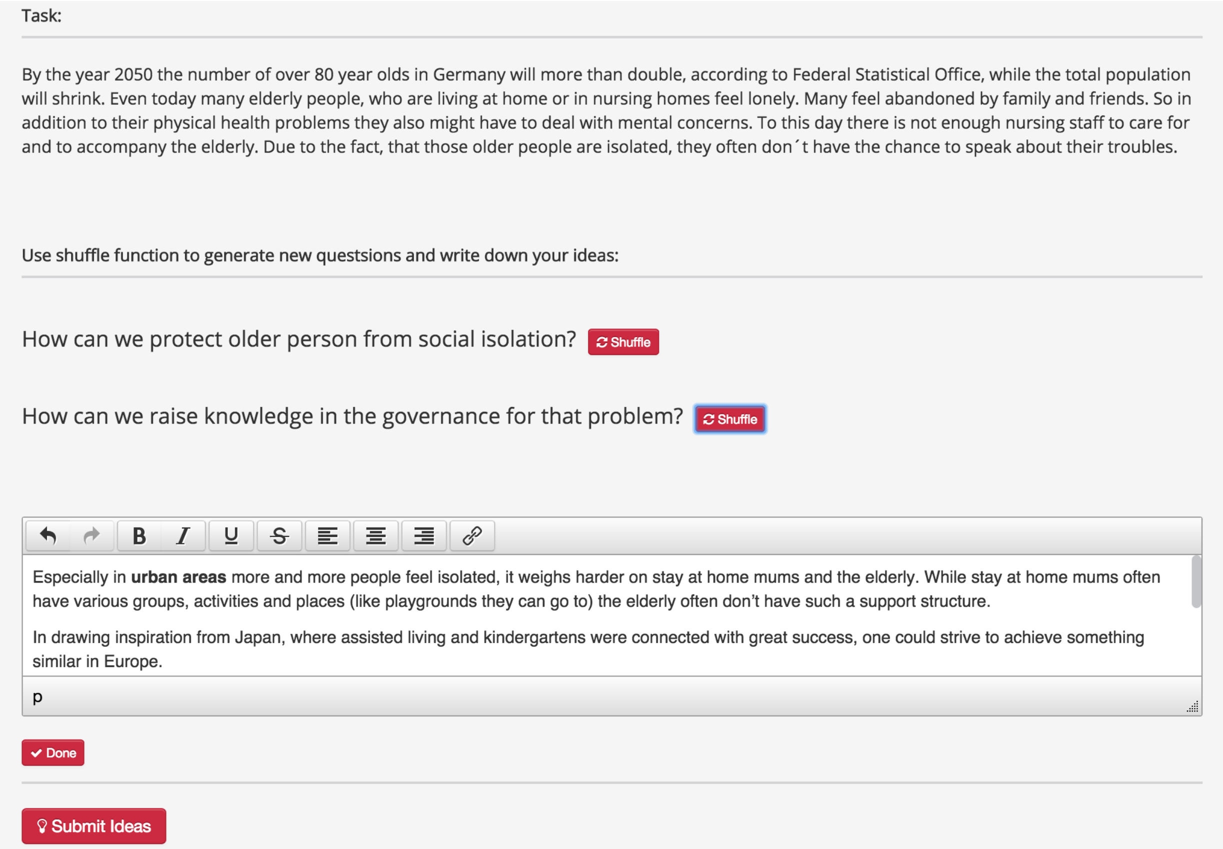

Figure 7.2: Idea Generation with Shuffle Function

7.4.2 Experiment

With overall 39 participants (13 females and 26 males), we conducted an experiment to validate our two hypotheses. The participants were undergraduate and graduate university students, who were recruited in the course of a lecture, whereas participation was not obligatory. University students show a high entrepreneurial interest and behavior (Wang and Wong, 2004), leading us to choose them as participants. Even so, studies have shown that entrepreneurship programs can furthermore raise entrepreneurial activities (Souitaris et al., 2007), our participants did not enroll in specific entrepreneurship programs. The students had majors in the fields of technology-oriented business administration, industrial engineering or computer science. First, we divided the participants into a group of task generators, idea evaluators or idea generators. The first two groups contained five participants each, whereas the group of idea generators had 29 participants. In order to create unrelated and individual tasks, the task generators formulated a problem that the idea generators should address in their idea. The main prerequisite given was that the task should be common and not require specific topic-related knowledge. For the core questions, the stated algorithms generated different synonyms and related words, which were added by the task generator (see figure 7.1). Overall, five different tasks were generated. Four tasks had two core questions and one task had three questions. Overall 174 automatically generated synonyms and related words were generated and selected for all five tasks. On average, 35 words were used for each task and approximately 17 words composed each question. Table 7.1 exemplarily presents one task with its two manually generated questions (Q1 and Q2) and three automatically generated questions (Alt). Stop words without synonyms are greyed out.

Task	By the year 2050 the number of over 80 year olds in Germany will more than double. Many feel abandoned by their family and friends. So in addition to their physical health problems they also might have to deal with mental concerns. To this day there is not enough nursing staff to care for and to accompany the elderly. Due to the fact that older people are isolated, they don't often have the chance to speak about their troubles.
Q1	How can we protect older person from social isolation?
Alt1.2	How can we keep back older parent from social non-engagement?
Alt1.2	How can we protect older handicapped person from social non-involvement?
Alt1.3	How can we preserve older deaf person from social disconnectedness?
Q2	How can we raise attention in the society for that problem?
Alt2.1	How can we increase knowledge in the governance for that matter of fact?
Alt2.2	How can we build care in the family for that question?
Alt2.3	How can we improve work in the community for that situation?

Table 7.1: Exemplary Task with Two Questions and Three Alternatives Each

The participants had four days for the formulation of the tasks. After that, the idea generators created an idea for a chosen task, for which we divided the participants into a test group (TG) and a control group (CG). The test group had the benefit of using the shuffle functionality to obtain additional stimuli. Participants were divided randomly, making up a control group of $p_{CG} = 15$ participants and a test group of $p_{TG} = 14$ participants. Both groups received the same instructions: use the system to create an idea addressing one chosen task. The task selection was nearly evenly distributed in both groups. However, three tasks with accordingly six, seven and eight ideas were preferred and two tasks had only four ideas. However, both groups addressed every problem at least once. For the idea generation, a time limit of four days was given to the participants. As every idea generator created a written idea, 29 ideas with an average length of 221 words, were composed. After the ideation, the idea generators (TG) participated in a short survey to evaluate the experience and the perceived effectiveness by the provided questions and the shuffle functionality. Details on the measurements and the idea evaluation procedure are presented in the next section.

7.4.3 Measurements

Five judges assessed the ideas after the idea generation process. Each judge evaluated every idea, although one judge unintentionally neglected two ideas leading to an overall number of 143 evaluations. Within our research, we narrowed our assessment to idea quality, as we did not ask our participants to generate as many ideas as possible. The group of idea generators was asked to focus on one idea and concentrate on its diversity. Therefore, the respective idea should cover larger areas of a possible solution space instead of a variety of ideas covering different aspects (Knoll et al., 2015). By doing so, we aimed to receive more comprehensive ideas, which we hypothesize to be more novel. We followed the eight dimensions proposed by Dean et al. (2006). These eight dimensions cover an extensive variety of observations like the novelty and originality of an idea, up to the completeness and the implementability (Dean et al., 2006). In our research, we concentrated on the effect of the creative stimuli on the idea generator, which is why we additionally evaluated the influence of the semi-automated questions by assessing the aspects and diversity of each idea. As mentioned before, start-ups often rely on only one idea, which constitutes to the base of the start-up. In order to evaluate whether our artifact produces more comprehensive ideas and whether the divergent process was effectively supported, we specifically measured the diversity of the ideas. The diversity of information has already been linked to opportunity identification of entrepreneurs (Gielnik et al., 2012). Therefore, we added the dimension diversity and the number of aspects of the idea to examine how versatile the idea was and how many paradigms and aspects were illustrated. These dimensions aimed to analyze whether the semi-automated questions were able to stimulate new aspects during ideation. We evaluated this by rating the idea, as an idea, which either considered only one aspect (1), some aspects (2), a few aspects (3), many aspects (4) or a lot of aspects (5). This measure aims to subjectively measure the perceived diversity of the idea, without giving a precise number of aspects. As the diversity of the generated ideas is a key aspect, we additionally asked for an actual number of aspects. We measured the diversity on a Likert-scale to get a relative answer on how the judges assessed the idea. The number of aspects is measured to receive a precise number and additionally serves as a control measurement. Both measures were rated in a roughly uniform manner, with a Pearson's product-moment correlation (diversity and number of aspects) of $r = .72$. Table 7.2 presents the dimensions and their sub-dimensions assessed by the idea evaluators.

Dimension	Attribute	5-point scale
Novelty	Rarity	From 1=highly rare to 5=not rare at all
	Originality	From 1=highly original to 5=not original at all
	Paradigm Relatedness	From 1=paradigm preserving to 5=paradigm modifying
Relevance	Effectiveness	From 1=highly effective to 5=not effective at all
Stimuli	Diversity	From 1=only one aspect to 5=a lot aspects
	Number of aspects	Natural number

Table 7.2: Measurements of Idea Quality and Diversity

The judges had two days for the assessment of the ideas and participated in a brief training on how to judge ideas, as suggested by Dean et al. (2006), prior to the evaluation, to ensure an identical understanding. Before starting with the assessment, the judges read every idea first, in order to get an overview of the overall quality. During the idea evaluation, the system also provided information about every dimension to the judges. The assessment was done with a five-point Likert-scale, excluding the dimension number of aspects, where a natural number was necessary (see table 7.2). The results of the post idea generation survey and the idea assessment are presented and discussed in the next section.

7.4.4 Results and Discussion

The idea generators participated in a survey after the creative process. This survey aimed to evaluate the effect of the semi-automated questions. Only the test group ($p_{TG} = 14$), who used the shuffle function, participated in this survey. The following table shows the questionnaire and the results. We used a five-point Likert-scale for the responses (1=strongly agree, 2=agree, 3=neither agree nor disagree, 4=disagree, 5=strongly disagree).

Question	Results ($p_{TG} = 14$)
Likert-scale	1 2 3 4 5
The semi-automated questions helped me to generate my idea.	5 3 4 1 1
Due to the semi-automated questions I considered more aspects for my idea.	3 5 5 1 0

Table 7.3: Absolute Data of the Post Idea Generation Survey

These results give first evidence regarding the capability of the shuffle function to stimulate the idea generator, influence the creative outcome and expand the solution space. Subsequently, the five judges evaluated if there was a positive influence by assessing every idea. To obtain a representative evaluation of each idea, we calculated the mean (M) values of the five judges for the dimensions rarity, originality, paradigm relatedness, effectiveness and diversity. For the number of aspects, we used the actual number given by each judge. To evaluate the significant difference between the test group and the control group, we calculated a set of Mann-Whitney U tests (Gibbons and Chakraborti, 2011; de Winter and Dodou, 2010). Table 7.4 shows the results of the Mann-Whitney U tests for the dimensions rarity, originality, paradigm relatedness, effectiveness, diversity and number of aspects.

Dimension	M_{TG}	M_{CG}	SD_{TG}	SD_{CG}	W	ρ
Rarity	2.604	4.023	0.783	0.378	10.5	.000038
Originality	2.614	3.700	0.742	0.533	25.5	.000512
Paradigm relatedness	2.850	2.067	0.698	0.595	165.5	.008441
Effectiveness	2.229	3.070	0.613	0.470	30	.001074
Diversity	2.825	1.653	0.834	0.367	191.5	.000165
Number of aspects	3.580	1.944	1.788	1.578	3805	.000000025

Table 7.4: Results of the Mann-Whitney U Tests (95% CI)

The Mann-Whitney U tests show a statistical significant difference between the test group and the control group. The test group produced ideas that were more original, rare and paradigm modifying. In their article, Dean et al. (2006) state that ideas can only be judged as novel if all three sub-dimensions have a score of at least the mean of the scale. An idea is therefore judged as novel, when rarity and originality scores are lower or equal to three and the paradigm relatedness score is higher or equal to three. Of overall 29 produced ideas, only five ideas could be seen as novel. All five ideas were produced in the test group with the semi-automated questions. In addition, all five ideas scored well (lower or equal to three) on the dimension effectiveness, which states that the ideas are not only novel, but also judged as effective problem-solutions. The mean diversity value ($M = 3.310$) and the average number of aspects ($M = 4.030$) is also higher then the mean value of all ideas. The post idea generation survey indicated that the participants were influenced during the idea generation process. The participants of the test group stated that the shuffle function supported the idea generation and that more aspects were considered. The assessment of the ideas confirmed this influence and showed that the creative stimuli, due to the additional questions, had a positive impact in the creation of overall better ideas. The Mann-Whitney U tests showed a significant positive effect on the idea quality, as the ideas generated by the test group were overall scored higher on the measures rarity, originality, paradigm relatedness and effectiveness. This supports our first hypothesis. Additionally, the first hypothesis is supported by the fact that all five ideas, assessed as novel and effective, originated due to the semi-automated generated questions. The Mann-Whitney U tests also validate our second hypothesis, as the ideas of the test group scored significantly better on the diversity dimension and covered more aspects. In addition, it can be said that the novel ideas are of higher overall diversity and consider more aspects, as their mean values lie over the overall mean value. Apart from one idea that scored lower on diversity and had a lower number of aspects than the average, all ideas scored higher on these two dimensions. In summary, all hypotheses are supported and a positive influence, due to semi-automated questions, exists. The additional semi-automated questions positively influenced the idea generation and resulted in ideas, which are more diverse and consider more aspects. Subsequently, with the help of our web-based artifact, the divergent thinking process could be effectively supported and more novel and diverse ideas could be produced, which can lead to new business opportunities. Thus, our experiment revealed that entrepreneurs could use the artifact to produce ideas that are more diverse and novel. Based on these novel and diverse ideas, a business model can be built. Additionally, the artifact did not only help to produce more novel ideas, but also more effective ideas, which could reduce the risk of failure.

7.5 Conclusion and Outlook

Our research offers both practical and scientific implications. Following the Design Science Research Methodology we created an innovative approach and implemented a unique artifact to address the identified problem and research gap. With this innovative artifact, we created an effective Creativity Support Tool that can be used by entrepreneurs. Our approach presents a possibility on how entrepreneurs can use information technology to enhance creativity in order to develop successful business models. The web-based artifact uses algorithms and word databases that offer comprehensive stimuli, such as synonyms and related words. The novel artifact and the underlying technology can be used to develop comprehensive CSS, which benefit from large databases that can stimulate the creative process. Due to the support of divergent thinking, the system opens a solution space for entrepreneurs and helps to recognize new opportunities, which are essential to develop innovative products or services. Our experiment showed that the artifact is capable of significantly supporting the idea generation process, leading to more novel and more diverse ideas, whereas we also showed that the created novel ideas had greater diversity and considered more aspects. This is helpful for entrepreneurs, as well as for established companies. Our research meets past findings on the effect of word stimuli and their effect on creativity (Hender et al., 2002; Knoll et al., 2015; Malaga, 2000). However, our research implication goes further, as we identified that this process can be executed automatically and that there is a significant enhancement on the novelty and on the diversity of the ideas generated with our web-based artifact. In our case, more creative stimuli resulted in better and more diverse ideas. This consequently limits our findings, as the actual amount of stimuli relates to the novelty and diversity of the ideas. Further research could examine different word stimuli and how the actual number of stimuli significantly influences the idea generation. In addition, we identified a positive relation between the diversity of an idea and the assessed novelty. Further studies could deepen the understanding and especially highlight the impact on entrepreneurial activities. The effect on the development and implementation of business models that originated from a supported creativity process should be examined. To effectively support entrepreneurial creativity, the concept of our artifact should be further developed and/or implemented according to the specific requirements of the start-up. With our artifact, we demonstrated that additional word stimuli can enhance creativity and especially support divergent thinking. However, the implementation of our proposed concept should be suitable for the context and situation of start-up companies. As mentioned before, the artifact can also be implemented within a GCSS, such as an electronic brainstorming system or a collaborative digital whiteboard. The potential of using automation to create creative stimuli is immense, since almost unlimited stimuli can be produced using information technology. Whether these are word stimuli, image stimuli or other stimuli, algorithms can expand the solution space of individuals and consequently present new business opportunities.

8 Paper 3

Anchored Discussion: Development of a Tool for Creativity in Online Collaboration

Abstract

Open innovation and crowdsourcing rely on online collaboration tools to enable dispersed people to collaborate on creative ideas. Research shows that creativity in online groups is significantly influenced by the interaction between group members. In this paper, we demonstrate how theory can be effectively used to design and evaluate a tool for creative online collaboration. Specifically, we use the body of knowledge on Creativity Support Systems to inform the development of a tool to support anchored discussions. Anchored discussions represent a new mode for creative interaction. In anchored discussion every comment is tied to some aspect of an idea. We evaluated the anchored discussion tool in a laboratory experiment, which generated insights for additional and refined research. Our results indicate that anchored discussion leads to a more structured discussion amongst group members and consequently to more creative outcomes. In a post session survey, participants made several suggestions on how to improve anchored discussion. This paper concludes that anchored discussion is promising as a new tool to aid online groups in creative collaboration. This paper extends a previous version presented at CRIWG 2015 (Link et al., 2015).

8.1 Introduction

Modern companies operate in a competitive and ever changing environment. New solutions are needed to meet the new paradigm of global competitiveness, which leads to rapid innovation in entirely new ways, e.g. (Germonprez and Levy, 2015). The innovation process relies on the ability to generate, evaluate, and refine ideas. Therefore companies are constantly searching for ways to develop innovative ideas. One approach to seek and develop innovative ideas concerns open innovation, which is the purposeful usage of internal and external sources for ideas (Chesbrough et al., 2006). More generally speaking, ideas can originate from a company's employees, suppliers, partners, customers, or other external parties. One way to allow these people to collaboratively innovate and make the resulting ideas accessible to the organization is the usage of online collaboration systems. These systems have the potential to evoke and enhance the creativity of a diverse set of participants (van Osch and Avital, 2009). Organizations that design and deploy online collaboration systems should adopt a theory-driven design method and account for the many factors that influence the creativity of individuals and groups e.g. (Amabile, 1983; de Vreede et al., 2012) so that they stimulate rather than discourage the creative process (Briggs et al., 2006). This is, for example, evident in the area of small group brainstorming. Early research demonstrated that blocking effects significantly reduced group productivity and creativity in traditional brainstorming groups where only one person can talk at a time (Diehl and Stroebe, 1987). Information System researchers developed collaboration systems where group members generate ideas simultaneously leading to higher levels of creativity and productivity (Fjermestad and Hiltz, 1998). A key challenge in open innovation and crowdsourcing is to enable online groups to generate creative ideas. Many open innovation systems have features for idea competitions or for collecting ideas straightforwardly, yet little support is offered to evaluate and refine ideas as a group effort (Hrastinski et al., 2010). However, when people collaborate and improve each other's ideas, the resulting ideas are likely to be more creative (Blohm et al., 2010; Yu and Nickerson, 2011). This is evident in an organization's use of an internal collaboration tool where engineers collaborate with employees from the field (e.g. support technicians who observe customers' use of products) in the creative task of developing products that better suit customers' needs (Bertoni and Chirumalla, 2011). We propose that new tools for online collaboration that are grounded in creativity and ideation theory have the potential to foster group creativity. Specifically, we follow a theory-driven design approach to design a tool that enables us to evaluate online anchored discussions as a mechanism to stimulate creative idea development. Anchored discussion originates from the field of education (van der Pol et al., 2006). Students' comments are tied to specific sections of the academic text and are shown next to it. Research shows that this design increases collaboration, knowledge sharing, and student engagement (Alrushiedat and Olfman, 2012). We propose to replace the academic text with a shared idea editor. Generated ideas can then be the center of an anchored discussion, which has the potential to stimulate a more structured collaboration process for elaborating and evaluating ideas.

8.2 Theoretical Foundations

8.2.1 Creativity in Groups

According to (Amabile, 1983, p. 33) "a product or response will be judged as creative to the extent that it is (a) both a novel and appropriate, useful, correct, or valuable response to the task at hand, and (b) the task is heuristic rather than algorithmic in nature." Research on creativity is often grouped into the Four P's of Creativity: person, process, product, and press (Rhodes, 1961). Early creativity research focused on describing attributes of creative people. More recent research focuses on the creative process and its products (Mumford et al., 2012). provide a model of the creative process, which consists of eight core processes: (a) problem definition, (b) information gathering, (c) information organization, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) solution monitoring. These eight core processes, which we will refer to as phases, can occur in different orders and loops due to the heuristic nature (Amabile, 1983) of the creative process. Especially within a group, it can be assumed that several of these phases occur simultaneously in different people. For example, (Sawyer and DeZutter, 2009) found that the interaction among group members can be a substantial source of creativity. This is evident in the reported case of a theater play in which actors construct the narrative in taking turns. One actor can make a new proposal for a development but the actual development of the narrative depends on how the next actor chooses to respond and what parts of the proposal they choose to continue. Sonnenburg (2007) specifically views creativity as something that results from the interaction of many factors. He reframed the 4P's of creativity research and developed the 1-5P-Model which describes the creative potential to be influenced by the factors: person, place, process, problem, and (proto-)prototype. The (proto-)prototype is the work-in-progress or preliminary outcome of the group process, which is transformed into the actual prototype - the creative outcome. From this point of view, the group members represent one factor (person) that influences the potential for creativity. Sonnenburg (2007) recognized that only people can start the creative process, but their interaction is influenced by other factors. The interaction amongst group members themselves is a key source of creative potential. This is demonstrated by the Team Creativity Model (TCM), which was developed in an exploratory field study (de Vreede et al., 2012). According to the TCM, the two main antecedents to group creativity are individual creativity and a Shared Mental Model (SMM). Especially the SMM is a direct result from the interaction of the group members. A SMM represents the extent to which group members have a shared understanding of the group situation and the task (Cooke et al., 2000). Shared understanding is the result of knowledge sharing, which requires clear communication (Bischof and Eppler, 2011). Clear communication is concise, has a logical structure, provides an explicit context and is low in ambiguity. To increase shared understanding, the interaction should be focused on a goal and aimed to help group members understand. Therefore, the TCM proposes that SMM acts as a mediator between knowledge sharing (i.e. interaction) and group creativity. Thus, following the logic of TCM, it is important to support diversity and independence to evoke creativity in individual participants (van Osch and Avital, 2009). Also, it is essential to lower the barriers for interaction and knowledge sharing between participants (Lugger and Kraus, 2001) to enhance the formation of SMMs. Based on past research and the logic of TCM we therefore hypothesize:

Hypothesis 1a. Group members reporting more similar SMMs will have more creative products.

Hypothesis 1b: Groups with a more structured and goal oriented interaction will report higher similarity in their SMM.

8.2.2 Individual Creativity and Group Creativity

According to TCM, individual creativity is a key antecedent to group creativity. It is also influenced by the interaction of the group members. This can be explained with the Search for Ideas in Associative Memory (SIAM) model (Nijstad and Stroebe, 2006). SIAM assumes that links between ideas in people's memory exist and that usually only ideas with a strong link to current thoughts are activated. A creative thought is characterized by two distinct, simultaneously active ideas that were not or only loosely linked before (Santanen et al., 2004). This activation can result from the interaction within the group or other outside stimulation. A common form of stimulation is to change perspective, which can occur in one of three ways (Knoll and Horton, 2010): (a) by searching for similar situations (analogy) and generating ideas for those situations; (b) by challenging assumptions (provocation) and using resulting situations for idea generation; or c) by using random elements and knowledge about them to generate ideas. Due to the social norm of not changing the subject and the tendency of building on other ideas, people have the tendency to voice similar ideas (Satzinger et al., 1999) and to not explore changes of perspective. Paradigm preserving (similar) statements elaborate on previous ideas and have value in building understanding. However, novel ideas are more likely to be paradigm modifying by introducing new elements or explore different relationships. It can therefore be argued that in the context of a creativity task the goal is to gain paradigm modifying ideas. Groups can be stimulated to explore a wider variety of ideas when giving diverse stimuli, for example from a computer algorithm (Siemon and Robra-Bissantz, 2014) or from a facilitator (Connolly et al., 1993; Santanen et al., 2004). The latter intervention method was informed by the Cognitive Network Model of Creativity, which draws a connection between the stimuli, cognitive load, and resulting creative thoughts (Santanen et al., 2000). Simply put, the model extends SIAM and posits that creative thought results from the combination of previously unlinked ideas, which is aided by a variety of stimuli, but impeded if the individual experiences high cognitive load. Cognitive load increases when many different ideas are active at once but cannot be combined into a chunk. Giving stimuli increases group creativity provided the prompts are well timed (Santanen et al., 2004). The research by Santanen and colleagues applies to co-located groups that have access to dedicated facilitation support. We are interested in determining how online groups can be supported without a professional facilitator who provides stimuli. When a group uses an electronic system to generate ideas, then only ideas that the group generated earlier can serve as stimuli (Satzinger et al., 1999). In terms of Sonnenburg's 1-5P-Model the (proto-)prototype is a collection of all previous ideas (Sonnenburg, 2007). The way in which the system displays previous ideas can influence the creative process (Javadi et al., 2013). Attention diversion and lack of attention to other people's ideas can both be the result of excessive exposure to other people's ideas. Following the logic of the Cognitive Network Model of Creativity, this is due to the increase in cognitive load among the group members. Javadi et al. (2013) propose to limit the number of displayed ideas based on a ranking derived from user votes. The same effect could be accomplished through a differently designed user interface that would separate different aspects of a problem into different dialogs (similar to different pages of a book) and thus separating the discussion (Dennis et al., 1997). Splitting idea generation into subcategories resulted in the generation of more ideas, more high-quality ideas, and more novel ideas. However, if a complex problem has multiple areas that could be subdivided but have a high interdependence, then the dependencies might not be considered if the problem is only viewed in subcategories and never as a whole. In summary, it can be argued that the way a group interacts will impact individual creativity and group creativity. The interaction is a stimulus for individual creativity. As a result individuals share their ideas and thereby stimulate creative thoughts in other individuals and overall impact group creativity. A better-structured and more goal-oriented interaction can reduce cognitive load and stimulate more diverse ideas. We thus formulate the following hypotheses:

Hypothesis 2a. The higher the creativity of individual group member, the higher the group creativity.

Hypothesis 2b. The more structured and goal-oriented the interaction among group members, the higher the individual creativity of the group members.

8.2.3 Anchored Discussion for Creative Online Collaboration

When a group uses an electronic system to collaborate, the design of the system shapes their interaction. Group members collaborating from separate locations and interacting only through a digital collaboration system are discouraged from social interaction but their writing efficiency may be boosted (Shah et al., 2015). Early electronic brainstorming research demonstrated that the negative effects of face-to-face groups, such as production blocking and evaluation apprehension (Diehl and Stroebe, 1987; Diehl and Stroebe, 1991), could be mitigated. Using electronic brainstorming can also enable larger groups to be productive, especially because they need not wait for each other to finish voicing ideas (Dennis and Valacich, 1993; Gallupe et al., 1992). To achieve positive results with such collaboration technology, designers have to ensure that the user interface supports the specific creative task. For example, an online group that works on the interconnection of ideas benefits from a diagram based collaboration tools that seamlessly links textual and graphical information (Azevedo et al., 2013). We build on previous research for designing a tool for creative online collaboration. Recently, Voigt and Bergener (2013) conducted a literature review to compile an integrated framework for designing group creativity support systems. To aid the development of group creativity support systems the framework provides 13 design principles and six components with different tasks within one system. For our research focus, the two components that are tasked to allow users to collaboratively generate ideas are relevant: shared idea editor and communication component. The related design principles are as following: (a) Provide the possibility to share ideas to foster mutual inspiration, (b) provide session histories and dialogue mapping, to support idea reflection and information storage to build trust within the group, and (c) support group awareness to avoid coordination problems and foster reciprocal inspiration. While these design principles address some of our hypotheses, they are not comprehensive. Additional design principles can be derived from the above literature review: (d) Limit the number of displayed ideas to reduce cognitive load (Javadi et al., 2013), (e) allow discussion and idea generation for different aspects of a problem to be separated (Dennis et al., 1997), and (f) provide a way to maintain the big picture, to allow groups to consider the relationships between different aspects (Azevedo et al., 2013). Based on these design principles, we argue that anchored discussion represents a viable system and user interface design. As explained earlier, anchored discussion originates from the education research literature and aims to allow students to collaboratively process academic literature (van der Pol et al., 2006). The user interface for an anchored discussion displays the article that students discuss on one side and the discussion on the other. "Anchoring is a process of creating reference points between parts of a document and comments in the discussion space to help prevent drifting within the context" (Alrushiedat and Olfman, 2012, p. 12). The advantages of anchored discussion are argued to include more meaning-oriented discussion, more frequent referring to content, fewer self-clarifications, fewer words needed to express ideas, increased sharing of ideas, enhanced participation, and improved engagement (Alrushiedat and Olfman, 2012; van der Pol et al., 2006). Anchored discussion is often compared to a forum discussion, which typically has participants focusing more on establishing social relationships and regulating the collaborative process. Also in forums there are more argumentations and confirmations. While the actual level of shared understanding may not increase through anchored discussion, researchers claim that less effort is required to reach the same level of shared understanding (van der Pol et al., 2006). This is because anchored discussion increases the efficiency and clarity of communication. To the best of our knowledge, there is no prior research on anchored discussions to stimulate creativity in problem solving tasks. We suggest to replace the academic literature frame with a shared idea editor. The original idea would always be present in the shared idea editor, so that the big picture is not lost. At the same time, using anchored discussion, separate subcategories of the overall problem can be discussed without interference of discussion of other subcategories. In other words, an anchored discussion for online idea generation will consist of a text editor and an area for comments. In the comments area only comments related to the currently selected text in the editor would be displayed. Thus, in-depth discussions can occur separately for each aspect of the whole idea. Additionally, the desired change of perspective occurs every time a user considers comments tied to a different aspect of an idea. The group would make changes to the original idea, based on the discussion. All comments should remain accessible, regardless of changes to the text in the shared idea editor.

Anchored discussion solves issues of clear communication, specifically related to the following (Bischof and Eppler, 2011):
• Writing concise content. Participants have to identify the most important aspects, leave out what is not required, and find simple and easily understood language. Anchored discussion focuses detailed discussion (including history) on only the one element of an idea that is in focus and thus encourages participants to rework this element based on the discussion.
• Building logical structure. This is a matter of how parts need to be connected. Anchored discussion always provides a connection between comments and elements of an idea.
• Providing an explicit context for discussion. By showing comments related to one element of an idea at a time, the context of the comment is explicit without the participant having to explain the context, thus reducing the effort needed for clear communication.
In summary, anchored discussion reduces cognitive load and fosters the emergence of SMMs by providing an environment that elicits clear knowledge communication. We propose that anchored discussion is well suited to enable an online group to better structure discussions of larger ideas. Thus, we hypothesize:
Hypothesis 3a: Groups that use anchored discussion will report higher SMM scores than groups that do not.
We further propose that anchored discussion reduces cognitive load because it limits the displayed comments to only those relevant to the subcategory a user is currently focusing on. Reduced cognitive load should result in higher levels of individual creativity (Santanen et al., 2004). Thus we hypothesize that:
Hypothesis 3b: Groups that use anchored discussion will produce higher levels of individual creativity than groups that do not.
We propose that SMM and individual creativity mediate between group interaction and group creativity. Consequently, if anchored discussion improves the group interaction, we hypothesize that group creativity will be improved as well:
Hypothesis 3c: Groups that use anchored discussion will produce higher levels of group creativity than groups that do not.

8.3 Method

Following the principles of theory-driven design, we designed and developed a technical artifact to evaluate our hypotheses (Briggs et al., 2006). Our artifact approaches our defined problem to increase creativity in teams based on the theoretical foundations described above and proposes a solution in terms of adding the anchored discussion functionality to a shared idea editor (Peffers et al., 2007). Our web-based artifact is a real-time synchronous editor with functionality that allows a group to work on the same text with all changes immediately visible to all members. The anchored discussion functionality provides the users with the ability to add comments to certain aspects of an idea. In our case, comments were tied to a specific line of the text. When a line of the idea was removed, comments remained accessible by merging them with the next line. Based on a user's current cursor position, the comments for this line would be visible, as depicted in figure 8.1. The actual idea is written within the shared idea editor and comments are arranged in a separate area to the right. The idea and comments are real-time synchronized so that everyone in the group can see changes and new comments immediately. For the control groups, the prototype was modified by disabling the anchored discussion functionality. Instead, a discussion function was implemented, which is similar to a one-threated forum. It basically represented a normal chat. Therefore, the control groups had no ties between comments and an idea, but still had a way of interacting, reach consensus by building on each other's ideas, and group learning (García-Álvarez et al., 2014). The interface looked the same as in figure 8.1 with the exception that the comment area behaved like a chat. The prototype was implemented as an extension of the open source software Firepad. Firepad is a reference implementation for the Firebase database by Firebase Inc., which is currently owned by Google. The MIT License allowed us to use and change Firepad without restrictions. Firepad is a real-time collaborative text editor, using the Firebase database to store and sync data in real-time. Firebase is available for many platforms, including iOS, Android, and Web. We used an API provided by a JavaScript library for web applications.

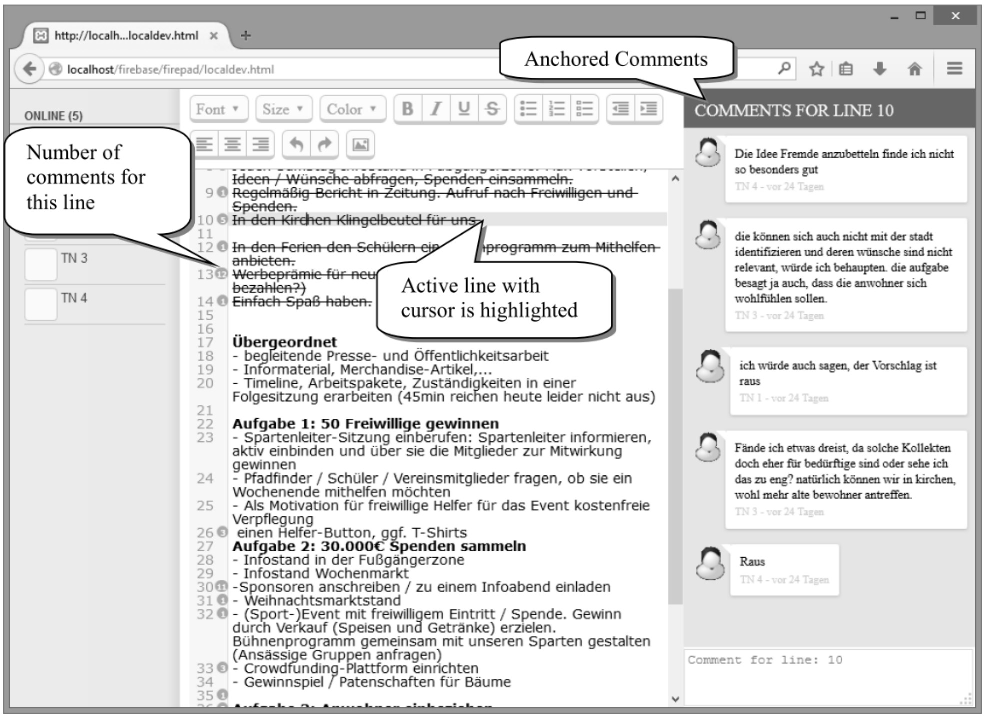

Figure 8.1: Screenshot of the Prototype

8.3.1 Experiment Structure

A laboratory experiment was conducted with 98 participants (64 male and 32 female). The participants were between the ages of 18 and 30 (M = 24.1, SD = 2.87). All participants were university students in a Western European university. They were undergraduate (44), graduate (52), and post-graduate (2) students with majors in different fields (48 management information systems, 32 industrial engineering, 9 computer science, and 9 others). Students were assigned to one of 26 groups of 3 to 5 participants each. The task for all groups was to use the prototype to collaborate as board members of a fictitious organization that wants to redesign the city parks. The city council requires the organization to organize volunteers, to collect donations, and to ask the people in the affected neighborhoods for their ideas on the park redesign. The group was provided with a few initial ideas of an absent board member. They were then tasked to refine these ideas and develop additional ideas. The experiment sessions were structured in three phases. During the introduction phase the participants were randomly assigned to groups and received an introduction into the prototype and the task. The second phase of the experiment was the collaboration phase, which lasted for 45 minutes. In the final phase a survey was issued to capture participants' perceptions and feedback. Two treatments were given. The first treatment, Treatment AD, included the prototype with the anchored discussion feature. This treatment was randomly assigned to 13 groups (48 participants). The second treatment, Treatment CD, was our control group and included the prototype with chat discussion. This treatment was also randomly assigned to 13 groups (50 participants).

8.3.2 Measures

Many researchers use an evaluation of the creative product as a proxy to assess the quality of the creative process (Dean et al., 2006). A creative product is "a product or response [that] will be judged as creative" (Amabile, 1983, p. 33). Since, there is no objective measurement, Amabile (1983) suggested to use subjective measurements by asking judges to rate the creativity based on provided dimensions. She found that judges reliably agree on what can be considered as creative, even without prior training. The dimensions to be rated by the judges can be tailored to the task that the creative outcome resulted from, but certain elements are predominantly present: novelty and quality (Dean et al., 2006). Dean et al. (2006) reported high inter-judge reliability on different problems when using their ordinal scales on eight different dimensions. For our study, four independent judges from diverse backgrounds evaluated separately the creativity of each group in random order. The creative outcome was rated on the eight dimensions by Dean et al. (2006), (1-4 scale for first six dimensions, 1-3 scale for last two): a) originality, b) paradigm relatedness, c) acceptability, d) implementability, e) applicability, f) effectiveness, g) implicational explicitness, and h) completeness. The authors demonstrated that these dimensions reliably measure novelty (a + b), workability (c + d), relevance (e + f), and specificity (g + h). The overall creativity is a combination of novelty and quality, which is measured by the other three constructs. Dean et al. (2006) recommend using thresholds on novelty and the three dimensions of quality, because a strength in one dimension cannot compensate for a weakness in another area. The goal was to compare creativity and thus a thresholds based on the respective means was created which separated the group outcomes into two groups on each dimension. Only when the creative outcome is in the higher rated group on at least three of the four dimensions, was the group considered to have created a creative outcome. The judges also rated how well-structured and goal-oriented the discussion within a group was. These dimensions were informed by the benefits that anchored discussion offers. The means of the dimensions formed an anchored discussion score (AD-score). A standard survey instrument, based on (Johnson et al., 2007), was used to capture the SMM. After each session, every participant was asked to rate 26 items (1 = strongly agree, 5 = strongly disagree). A group's SMM-score was calculated as the mean across participants' means across all items. The post-experiment survey also assessed participants' perceptions of effectiveness and satisfaction. These measures were adapted from previous research (Dennis et al., 1996). Another construct we measured was individual creativity. A common way to measure creativity is the good-idea count, by rating every submitted idea (Reinig and Briggs, 2006). However, the shared idea editor captures entries from every person as changes to the idea set. In other words, the final result represents the final transformation of the idea set. The prototype does not contain an algorithm to keep track of individual contributions or separate contributions. Thus it was not possible to determine who entered what idea or changed another idea in the text editor. Until we extend our prototype, individual creativity can only be measured by proxy. To this end, it was assumed that individual creativity can be expressed as the number of ideas presented to the group and assuming that this is related to the amount of text a participant enters into the prototype (Briggs and Reinig, 2007). Contributions were counted in terms of the number of characters added to the idea editor, the number of changes made in the idea editor, and the number of characters captured in comments. After the quantitative analysis, the first two authors evaluated the use of the prototype by analyzing the presentation of the final document, the discussions, and comments provided in the post-experiment survey (Thomas, 2006). We analyzed the use of different structuring elements including headlines, bullet points, and enumerations and their support for clarity and comprehensiveness of the idea. We further analyzed 2084 comments from the discussion within each group, coding for idea-related, organizing and task-unrelated comments. The first and second author coded independently to achieve inter-coder reliability and discussed their differences of judgment (Thomas, 2006). Lastly, we analyzed five pages of comments provided by 51 participants in the post-experiment survey. We highlighted comments addressing multiple aspects with different colors and recorded emergent themes.

8.4 Results

An independent samples t-test was conducted to compare the group creative score (sum of creativity dimensions) for groups that reported more similar SMM and groups with less SMM (H1a). We split the groups by median SMM. There was no significant difference in group creativity score for groups with more similar SMM ($M = 22.6, SD = 1.85$) and groups with less similar SMM ($M = 22.1, SD = 1.48; t(24) = -.78, \rho = .44$, two tailed). The magnitude of the differences in the means (mean difference $= -0.51$) was moderate ($\eta^2 = .02$). H1a is not supported. An independent samples t-test was conducted to compare the reported similarity of SMM for groups that had more structured and goal oriented interaction and groups that had less (H1b). We split the groups by median anchored discussion score (AD-score). The AD-score captures how well structured and goal oriented the discussion within a group was (from 1 = unstructured to 4 = well structured). Inter-judge reliability is high on four items (Cronbach's alpha: $.89$). There was no significant difference in reported SMM similarity for groups that had a higher AD-score ($M = 49.7, SD = 11.2$) and groups that had a lower AD-score ($M = 50.7, SD = 11.3; t(24) = .23, \rho = .82$, two tailed). The magnitude of the differences in the means (mean difference $= 1.01$) was small ($\eta^2 = .002$). H1b is not supported. To determine which groups produced a creative outcome, we counted the creativity dimensions for which the rating was above the dimension mean over all groups. Groups that reached at least the mean on three dimensions were considered to be more creative (see table 8.1). The inter-judge reliability on group creativity ranged from mediocre to acceptable, given the Cronbach's alpha (α) for the dimensions novelty ($.56$), workability ($.60$), relevance ($.51$), and specificity ($.74$). On workability we excluded the ratings of one judge as they showed a clearly different rating scheme.

	More creative		**Less creative**		
Number of dimensions rated above means	**4**	**3**	**2**	**1**	**0**
Anchored Discussion Groups (AD)	1	7	2	3	0
Control Groups (CD)	0	5	4	3	1

Table 8.1: Total Number of Groups (AD and CD) Rated According their Creativity Dimensions

An independent samples t-test was conducted to compare the average individual creativity for groups that produced creative outcomes and groups that did not (H2a). There was no significant difference in individual creativity for groups that produced more creative outcomes ($M = 2425, SD = 502$) and groups that had less creative outcomes ($M = 2082, SD = 708; t(24) = -1.42, \rho = .17$, two tailed). The magnitude of the differences in the means (mean difference $= -341$) was moderate ($\eta^2 = .07$). H2a is not supported. An independent samples t-test was conducted to compare the individual creativity for groups that had more structured and goal oriented interaction (i.e. higher AD-score) and groups that had less (H2b). There was no significant difference in individual creativity for groups that had a higher AD-

	M_{AD}	SD_{AD}	M_{CD}	SD_{CD}	t	ρ	MD	η
Group Creativity	22.6	1.66	22.2	1.67	-0.68	$.50$	-0.44	$.02$
Individual Creativity	2081	659	2426	563	1.44	$.16$	345	$.08$
Similar SMM	55.1	9.1	45.1	10.8	-2.55	$.02$	-10.0	$.21$
Perceived Satisfaction	2.76	0.61	2.36	0.57	1.72	$.10$	0.40	$.11$
Perceived Effectivity	2.49	0.45	2.13	0.41	2.17	$.04$	0.37	$.16$
AD-score	3.32	0.60	2.84	0.35	2.50	$.02$	0.48	$.21$

Note. M = Mean. SD = Standard Deviation. MD = Mean Difference. AD = Anchored Discussion (treatment). CD = Chat Discussion (control group). SMM = Shared Mental Model ranges from 26 (most similar) to 130 (least similar). Individual creativity by proxy number of contributions. Group Creativity ranging from 8 to 30 (most creative). Perceived Satisfaction and Perceived Effectivity range from 1 to 5 (best). AD-score ranges from 1 (unstructured) to 4 (well structured).

Table 8.2: Results of the Independent T-test, Two Tailed

score ($M = 2290, SD = 649$) and groups that had a lower AD-score ($M = 2212, SD = 623; t(24) = -.31, \rho = .76$, two tailed). The magnitude of the differences in the means (mean difference $= -78.1$) was small ($\eta^2 = .004$). H2b is not supported. An independent samples t-test (see table 8.2) was conducted to compare SMM similarity for groups of the different treatments (H3a). There was a significant difference in similar SMM between the treatments. The magnitude of the differences in the means was large. H3a is not supported, since lower SMM values indicate more similarity. An independent samples t-test (see table 8.2) was conducted to compare the average individual creativity for groups of the different treatments (H3b). There was no significant difference in individual creativity between the treatments. The magnitude of the differences in the means was moderate. H3b is not supported. An independent samples t-test (see table 8.2) was conducted to compare the levels of group creativity for groups of the different treatments (H3c). There was no significant difference in levels of group creativity between the treatments. The magnitude of the differences in the means was moderate. Even within the four dimensions of creativity (i.e. novelty, workability, relevance, and specificity) there is no significant difference between the treatments. Additionally, we compared the creativity dimensions for each group. A group would be counted as 1 on a dimension if their rating was above the dimension mean. Groups that reached at least the mean on three dimensions were considered to be more creative. 8 AD and 5 CD groups met this criterion. The results in table 8.1 show that groups with anchored discussion produced more creative outcomes. This supports H3c. We conducted further t-tests for the treatments, found in table 8.2: Perceived satisfaction (Cronbach's $\alpha : .82$) is not significantly different between the groups with a moderate magnitude of the differences in the means. Perceived effectivity (Cronbach's $\alpha : .75$) is significantly better for CD groups with a large magnitude of the differences in the means. The AD-score is much higher for AD groups with a large magnitude of the differences in the means.

8.5 Qualitative Findings

The analysis of the presentation of the final document, the discussions, and the comments in the post-experiment survey revealed interesting findings that shed light on the unexpected quantitative results. First, comments about structuring the idea with headings or bullet points were found early in all CD group chats. Sample comments read (translated): “I would say we structure this first” ”How about basing the layout off of the three points from the assignment?” “Should we reorder the list?” In comparison, with the exception of one group, none of the AD groups discussed structure to begin with. Only after realizing that deleting lines would merge comments and that moving text did not move comments did some AD groups consider structuring to prevent discussions from becoming diluted later. The presentation of the final document reflects this difference. While all thirteen CD groups used headings and bullet points to structure their final document only eight AD groups did so. The remaining AD groups produced a single text block with little formatting. Second, the discussion within CD groups focused sequentially on the different elements of the assignment. Before moving to a new topic, group consensus was often conveyed by confirmation messages such as (translated) “yes”, “agreed”, or a supportive emoticon (i.e. :-) or ^^). In comparison, within AD groups the discussion on different elements occurred and far fewer confirmation messages were observed. Rather, having made changes to the idea text seemed to have been sufficient and required no further comments. Third, our analysis of all 2084 comments supports that AD groups engaged in more clear and focused discussion. We coded each comment in one of three categories as either related to the idea, organizing the team, or non-related. Cohen's Kappa (κ) was run to determine if there was agreement between the first and second author's judgment. There was moderate agreement for the CD treatment, $\kappa = .539, p < .0005$, and good agreement for the AD treatment, $\kappa = .878, p < .0005$. For the CD treatment, both coders agreed that of 1218 comments 47.5% were idea-related, 20.0% were organizing the team, and 5.7% were off-topic. Of the 26.7% disagreement, the majority was about whether comments were idea-related or off-topic (11.0%), and idea-related or organizing (10.9%). This finding highlights that CD groups used many ambiguous comments. One common example was (translated): “I cannot think of anything more.” This comment could be a closing remark relating to an idea or an organizing statement that the discussion should move on. One example of an idea/off-topic disagreement is found in one group that went off tangent to discuss providing free beer to volunteers, which has the potential to spark ideas but is not clearly related to the idea. These ambiguous comments were most prevalent in CD groups. For the AD treatment, both coders agreed that of 866 comments 78.4% were idea-related, 7.2% were organizing, and 10.3% were off-topic. This finding supports that AD groups were engaged in a more focussed discussion on the ideas. The surprisingly high rate of off-topic comments resulted from discussions about the prototype. Fourth, many AD group members commented that at first they did not understand how to use anchored discussion. This was evident in the discussion as well as the comments in the post-experiment survey. One AD user commented afterwards (translated): "A longer introduction to the web-app would have been good (maybe demonstrate the use with projector). It was not 100 % clear, how the thing worked, that took a few minutes. That could have been demonstrated and everyone could have started on the task right away." One AD group went as far as to discuss the bugs of the prototype towards the end of the session. In the post-experiment survey, emergent themes included the excitepment for anchored discussion (9 participants), a wish that new comments would be indicated for each line (7 participants), a bug where the prototype stops synchronization and ideas entered are lost (5 participants), and unintuitive use of the tool (3 participants). In contrast, CD groups discussed the prototype far less during the session or afterwards and focussed more on the group dynamics. In the control group, emergent themes from the post-experiment survey addressed the sense of unplanned, unstructured and chaotic interaction (3 participants), a preference for face-to-face group meetings because it reduces chaotic interaction (2 participants), and the unstructured nature of the task description (2 participants). Last, four CD groups created a custom anchored discussion within the text editor. Comments directly related to a specific text were added into the shared idea editor, often marked as a comment by putting "->" in between text and comment. This was unique to CD groups.

8.6 Discussion

Based on our theoretical foundation regarding group creativity in an online environment, we designed and implemented a first version of a tool with anchored discussion. The results seem to not support most of our hypotheses. Below we will explore possible explanations. In hypotheses 1a and 2a, we proposed that the SMM of the group and the individual creativity (estimated by contributions as a proxy) of the group members would influence group creativity. These hypotheses are derived from the TCM (de Vreede et al., 2012), which proposes a relationship between SMM and individual creativity to group creativity. Both antecedents differed in the results between the treatments: the control group had the more favorable results in both cases. However, group creativity appears to be unaffected by this. This could indicate that some other factor was involved and that the relationship as stated in the TCM is different from how we tested it. Furthermore, de Vreede et al. (2012) mentioned that a less similar SMM could be beneficial to group creativity, which might partly explain why the anchored discussion groups had a less favorable SMM-score but had slightly better creative outcomes. In theory, a more structured and goal oriented group interaction was supposed to positively influence SMM and individual creativity, as stated in hypotheses 1b and 2b. The results did not support these hypotheses. The same observations from the previous paragraph apply. Anchored discussion did enable the groups to have a more structured and goal oriented discussion with less needs to create references to the text, fewer interactions organizing the teamwork, and as a result require less discussion. The AD-score and qualitative findings clearly indicate that anchored discussion produced a more efficient interaction amongst the group members. However, hypotheses 3a (higher SMM-score for groups using anchored discussion) and 3b (higher individual creativity for groups using anchored discussion) are not supported by the results. Interestingly, the groups using anchored discussion had a more structured interaction, but SMM, individual creativity, satisfaction, and perceived effectiveness scores were less favorable than in control groups' scores. However, in support of hypothesis 3c, but contrary to our hypotheses 1a and 2a, the group creativity was slightly better in anchored discussion groups. A possible explanation could be limitations to our measurements. However, we used validated measures for group creativity, SMM, satisfaction, and perceived effectiveness. We acknowledge that using the contribution count as a proxy for individual creativity is arguably not preferable, and results in not being able to reliably support or refute hypotheses 2a, 2b, and 3b. The qualitative analysis of the final document, the discussions, and comments from participants on the post-survey can aid the search for explanations. Participants were asked to comment on the experiment afterwards. A reoccurring theme was that participants were overwhelmed by anchored discussion and did not intuitively understand how to use it, which clearly showed in analysis of the discussion. Participants commented that they would have preferred a more detailed explanation of how to use anchored discussion and maybe even have an additional training before the actual creative task was assigned. It can thus be argued that the unknown interface of anchored discussion caused a cognitive load that impeded on the collaboration task. However, giving an introduction on how to use the anchored discussion tool effectively could influence the reported levels of perceived effectiveness and thereby interfere with the measured results. The negative effect of our prototype on satisfaction and perceived effectiveness could be further explained by some unexpected behavior. One anchored discussion group noticed early that deleting a line in the shared idea editor results in the attached comments to be combined with the next line and thus diluting that other discussion. The group's solution was to write into a line "[deleted]" and thereby maintaining all the comments separate. Other groups interrupted their creative process to structure the document and thereby structuring subsequent discussion threats. We therefore conclude that a software design in which comments are moved to a different space if they become orphaned due to a deleted anchor would be better. Also participants asked for comments to be tied to the text and thus be moved with the text, if the text is rearranged. One group left the lines with comments in the original order to maintain all comments and compiled the fully developed plan below in new lines. The inhibiting effect of the prototype is most evident in the format of AD groups' final documents, which often lack structuring headings and bullet points. In summary, this unintuitive behavior also appeared to increase cognitive load and reduce perceived effectiveness and satisfaction. While the effect was strongest on the antecedents, the more structured discussion appeared to compensate for this resulting in the group creativity being slightly above the control group. This is remarkable in the light of the off-topic discussion concerning the prototype within AD groups, which further distracted from the task. Continuing with participants' suggestions for improvements, the most requested feature was a visual indication that an unread comment existed. In our prototype the number of comments were displayed next to the line number, and when this number increased no visual cue was provided. One participant explained the downside of this implementation (translated): "Some comments were never noticed." We had not implemented this feature to avoid distraction and to not disrupt the creative thought process. However, it seems that a non-obtrusive change of color or font style for the comment count could aid the collaboration of the group members by reducing the time in search for new comments. Only participants in the control groups argued that they would have liked additional support to structure their collaboration process. The analysis of the discussion demonstrated that CD groups put much effort into structuring the document and coordinating the discussion. Headings and bullet points were mostly used by CD groups, but apparently did not satisfy the need for coordination. Suggestions for more support included to-do-lists and voting features. The communication was described in some comments as unstructured, having too many conflicts, and not being goal oriented. One comment described in detail how the constant stream of comments in the chat area caused attention diversion and prevented creative work in the shared idea editor. Interestingly, four of the 13 control groups helped themselves and created their own anchored discussion within the text. Thus we can see how anchored discussion is a promising solution for structuring text related discussions. The effectiveness is supported by the fact, that three of the four groups were rated as having created a creative outcome. If we had counted the groups with self-build anchored discussion to the AD group, then 11 AD and 2 CD groups are rated as creative. This would strongly support hypothesis 3c and indicates the benefit of anchored discussion to increase creativity.

8.7 Limitations

Our research has several limitations. First, the standard limitations of a lab experiment apply. For example, students were encouraged to participate but may not have had any intrinsic motivation to do so. When anchored discussion is used on social media platforms where people collaborate only voluntarily, different motivations and incentives may apply so a field evaluation of anchored discussions is recommended. Also, the fictitious experiment task may not have stimulated creativity and participation equally for all students. Additional limitations are related to the prototype. Many participants complained about the performance and attributed slower collaboration to this aspect, but this was consistent for both treatments. Additionally, as argued above, the functionality of anchored discussion was unknown to the subjects. Prior training might have aided performance and yielded different results. Better results might have also been achieved if the participants' suggestions were implemented and the stability was improved. The design of our prototype did not allow us to perform personalized idea counts, which would be a preferred measurement for creativity (Reinig et al., 2007). Using number of characters typed as a proxy for individual creativity has several drawbacks. Contribution counts could be high for other reasons, like correcting spelling mistakes, or communicating unrelated messages. However, using the count of good-ideas would be a more correct measurement, especially since the ratio of good-ideas to total ideas can serve as an indicator for cognitive inertia experienced by the group (Briggs and Reinig, 2007), which anchored discussion should reduce. Thus, comparing contribution counts has limited value in comparing individual creativity between control groups and anchored discussion groups. Finally, the dimensions from (Dean et al., 2006) appear to be a better fit for evaluating many ideas that are created after another, and not so much for evaluating the overall creative outcome. This can be demonstrated on the dimensions originality and paradigm relatedness, which both are better judged in comparison to previously created ideas, but are difficult to judge without reference points. Another limitation in our evaluation of the creative group outcome is that we did only a short training with the judges, because (Amabile, 1982) suggested it was not needed, and not as extensive as was suggested (Dean et al., 2006).

8.8 Conclusions

We successfully demonstrated that the body of knowledge on creativity provides a sufficient foundation to inform the development of new tools to support creativity. Based on the body of knowledge we designed and developed a prototype that used anchored discussion and evaluated it in an initial experiment. Our experiment revealed that anchoring is an adequate tool to structure an ideation process and has the potential to enhance performance. The participants used anchored discussion or created their own anchored discussion-like functionality. This suggests that anchoring is effective to structure the communication in a creative process. Further, the results suggest that groups using anchored discussion are working in a more structured way. However, our study revealed the most important issue of any creativity tool, which is usability. As the design of the system shapes the group interaction, the implementation of anchored discussion also influences group performance, even impairing creativity, if inappropriately designed. Our work provides tested design guidelines and suggestions for improvements. Most importantly, structuring group work using anchored discussion should be intuitive and not overstrain the user, leading to high cognitive load. To summarize our findings, anchored discussion seems promising. From the experiment we expected stronger support for our hypotheses, yet it has to be considered that this was the first prototype to explore the use of anchored discussion for creativity in online groups. We have gained a better understanding of what can be improved. Our contribution is twofold. First, we demonstrated how theory can serve as a foundation to inform the design and development of new collaboration tools. Second, we advise future research on how to build better prototypes using anchored discussion to increase the creative quality of online group ideation. In addition, we initiated the idea of implementing anchored discussion into a variety of group support systems, where individuals work together in a shared editor. Anchored discussion has the potential of improving group work, such as joint decision-making, joint evaluation, joint problem solving, or other group processes. Even so, the implementation of anchored discussion probably needs appropriation for different contexts. Our findings reveal the most important issues and provide valuable insights for designers and developers of creativity support systems.

8.9 Future Research

There are several promising avenues for future research. To date, anchored discussion has not been evaluated for creative tasks. Our first prototype was positively received by participants, who made some suggestions for an improved design. Further research could incorporate and improve the usage of anchored discussion in creativity support systems and other group support technology. Comprehensive tasks and problems can be separated into different aspects to reduce cognitive load, while still maintaining the big picture. Our research results can therefore be seen as informing future design guidelines on how to implement anchored discussion into group support systems. Additional insights could be generated, if the divergent and convergent creativity process were measured independently. The influence of anchored discussion on the different creativity processes could aid in understanding the underlying principles of anchored discussion. This could reveal whether the structuring of content is desirable for either the divergent stage or the convergent stage of the creativity process. This could also increase a more comprehensive understanding of anchored discussion. In social media, crowdsourcing, and open innovation processes, people are more likely to contribute when a task is enjoyable, easy to understand, rewarding, and when it creates a state of flow. Further research could evaluate the effect of anchored discussion on these dimensions.

9 Paper 4

Forming Virtual Teams - Visualization with Digital Whiteboards to Increase Shared Understanding, Satisfaction and Perceived Effectiveness

Abstract

To achieve effective virtual teamwork, suitable Information Technology (IT) that effectively support the formation of virtual teams must be identified. This paper presents an experiment on testing how to use IT to increase shared understanding, satisfaction, and perceived effectiveness in the forming phase of virtual teamwork. We applied the psychological construct of Shared Mental Models (SMM) - more specifically the knowledge structure team task, goal and performance requirements - to evaluate whether the collaborative visualization of a wicked problem with a digital whiteboard can support team members in building SMM. Our results from the experiment reveal that the usage of a digital whiteboard positively affects team interaction, satisfaction, structure and understanding and hence, team performance. Furthermore, the results support findings from prior research that richer media, which allows for synchronicity within communication enhances the communication process.

9.1 Introduction and Motivation

Innovations in Information Technology constantly change corporate communication and collaboration. IT-based, location-independent teamwork influences business routines and collaboration patterns (Lurey and Raisinghani, 2001). The physical and geographical dispersion of companies and workers is no longer a barrier for collaboration (Lurey and Raisinghani, 2001). However, virtual teamwork requires different tools and mechanisms than face-to-face teamwork. Virtual teamwork can be performed in different settings and for different purposes, which leads to the adaptation and development of specific tools for the interaction among humans and computers (Raghuram et al., 2010). Teamwork is generally not limited to any occupation, division or organization, which indicates the relevance of the topic for diverse areas (Salas et al., 2000). Workers are constantly confronted with new and challenging tasks and tools (Schouten et al., 2016), thus changing work habits, tasks, and performance (Lurey and Raisinghani, 2001). To achieve effective virtual teamwork, the interdependences of individual workers, teams, IT, and tasks must be understood (Kanawattanachai and Yoo, 2007; Lurey and Raisinghani, 2001; Bartelt and Dennis, 2014). Identifying suitable means to effectively support the formation of virtual teams would make a significant contribution to the knowledge base on virtual teamwork and will also enhance existing literature. Furthermore, the research would allow practitioners to implement adequate visualization tools, because "[a] well-designed team-based organization can expect to see better problem solving and increased productivity, effective use of company resources, better quality products and services, increased creativity and innovation, and higher quality decisions." (Lurey and Raisinghani, 2001, p. 542). In this contribution, we raise the following research question: can IT, which enable collaborative visualization, enhance the effectiveness of virtual teams in the "forming" phase of projects? In the forming phase, team members build a common understanding and knowledge of the underlying tasks, goals, and intentions (Tuckman, 1965). Effectiveness, in the context of this paper, relates to the individual perception of team members' shared comprehension of team task, goal, and processes, as well as their perceived satisfaction. We conducted an experiment where virtual teams visualize their tasks collaboratively to understand a wicked problem in order to initiate a team process. The term "wicked problem" can be traced back to Buchanan (1992). Wicked problems are indistinct, have innumerable causes, have no right solution and are solved in the way designers think (Buchanan, 1992). The designer's perspective indicates a visual approach to solve wicked problems. To evaluate the applicability and effectiveness of our virtual tool from a human-centered perspective, we used the measurable psychological construct of SMM. In the first section of this paper, we will discuss the overall challenges of (virtual) teamwork as well as those found in the forming phase. We will also reflect on given media theories such as Media Media Naturalness Theory (MNT), Media Synchronicity Theory (MST) and Media Richness Theory (MRT). Secondly, we will outline the concept of visualization in regard to digital whiteboards. Thirdly, we will discuss the role of SMM in the context of visualization and wicked problems, as well as introducing our propositions. Fourthly, we will concentrate on the methodology and explain our artifact (i.e. the virtual tool), our experiment, our survey, and our results (Hevner et al., 2004). Fifthly, we will discuss our results in regards to findings mentioned in relevant literature. Within the conclusion, we reveal that our artifact, the virtual tool for collaborative visualization of wicked problems, increases the level of SMM, including an increased satisfaction level, and an increased perceived effectiveness by team members.

9.2 (Virtual) Teamwork and the Forming Phase

9.2.1 Characteristics and Phases of Teamwork

The term "team" is defined as a group of individuals who work collaboratively with a shared intention in order to reach a specific target (Lurey and Raisinghani, 2001). In past research, specific characteristics of teamwork have been discovered: firstly, team members are supposed to work independently and collaboratively, in a manner that needs to be coordinated and harmonized (Salas et al., 2000). Secondly, the team environment is changing due to task and team settings, which demands revaluation and adjustment for team tasks and processes, which are highly connected to communication. Thirdly, the dynamic exchange of team- and task-relevant information is one of the challenges of teamwork. Fourthly, teamwork is characterized by always having a limited time span, as well as a shared vision. Tuckman (1965) determined the following phases of teamwork: forming, storming, norming, performing, and adjourning (Tuckman, 1965; Tuckman and Jensen, 1977). The forming phase is characterized as an orientation through testing the constraints of behavior towards tasks, members and leaders, which is followed by building interdependencies that are highly connected to team building processes. As such, the forming phase is an inevitable phase for collaborative teamwork, where, among other things, a SMM is constructed and the basis for the following collaborative process is established. The storming phase is characterized by conflicts and polarization, followed by norming, where new standards arise and interpersonal roles are set. In the performing phase, teams channel their ambitions towards team tasks and team goals (Tuckman, 1965). The adjourning phase closes and dissolves teamwork (Tuckman and Jensen, 1977).

9.2.2 Media Theories – Challenges and Opportunities of Virtual Teamwork

When comparing virtual and face-to-face teams, advantages as well as disadvantages of virtual teams can be found. In contrast to face-to-face teams, virtual teams challenge the interplay of verbal- and non-verbal communication in physical surroundings (Schouten et al., 2016), which limits the visual perception of human and environment interaction (Kanawattanachai and Yoo, 2007; Bartelt and Dennis, 2014). The Media Naturalness Theory, which builds on human evolution ideas, posits that the use of communication media suppresses key elements found in face-to-face communication, which ends up posing cognitive obstacles for communication (Kock, 2004). This is particularly the case in the context of complex tasks (Kock, 2004). It has to be outlined that virtual teams are enabled for multichannel-communication in comparison to one-channel face-to-face conversation, e.g. communication in forums and simultaneous connection of team members via phone, video-chat, etc. (Schouten et al., 2016). In this context, the Media Synchronicity Theory posits that communication will be enhanced when the synchronicity of a given medium can appropriately support the synchronicity that a communication process requires (Dennis et al., 2008; Dennis and Valacich, 1999). The MST focuses on the capability of media to support synchronicity, which is defined as a "state in which individuals are working together at the same time with a common focus". Hence, virtual teams are dependent on electronic devices, which causes restrictions in resource access, e.g. internet and specific software access, but also leading to the opportunity of quickly presenting visual material such as data, graphs and photos, among other things (Schouten et al., 2016). In this regard, the Media Richness Theory explains that richer, personal communication media is generally more effective for communication of equivocal issues than leaner, less rich media (Daft and Lengel, 1986). This dependence and likewise opportunity forces virtual teams to apply IT (Hollan et al., 2000). In addition, IT facilitates the creation of virtual teams without boundaries of specific areas or disciplines, which results in multidisciplinary teamwork and fitting competencies of team members due to team tasks and requirements (Thomas and Bostrom, 2007). Furthermore, virtually performed teamwork enables flexibility in terms of tasks, schedules and team formation, as well as an adaptation of working life in organizations (Lurey and Raisinghani, 2001). In the forming phase of teamwork, a common understanding and knowledge of the underlying tasks, goals, and intentions by team members need to be developed. This is a challenge since virtual teams naturally have performing restrictions in the forming phase, as communication channels are limited due to the functionality of the applied IT (Kirkman and Mathieu, 2005; Thomas and Bostrom, 2007; Warkentin et al., 1997).

9.3 Virtual Visualization as Teamwork Facilitator

According to the MRT, there is a need for a tool that allows rich and personal communication. Additionally, the tool should support synchronous communication to fulfil the requirements of the communication process. In our research, we introduce the concept of "visualization" to support the forming processes of teams. In the given context, visualization can be understood as a part of a Creativity Support System (Gabriel et al., 2016; Shneiderman, 2007), which fosters the development of mental images (Rouse and Morris, 1986) and builds the basis for various creativity techniques (Resick et al., 2010).

9.3.1 The Concept of Visualization

Generally, the concept of visualization inherits an internal and external scope, whereas internal representation means "to form a mental image of" (Santos et al., 2015, p. 1) a given content and is understood as a cognitive process, and external visualization refers to tangible visual representation of given content (Ware, 2012). On an individual level, an internal representation can be transformed to an external visual artifact to support reasoning (Ware, 2012). In terms of teamwork, several mental images/models need to adapt to team task, goal and requirements.

In order to create a shared understanding of several single mental models, a collaborative development of one external visualization supports reasoning and progress (Swaab et al., 2002). Furthermore, the possibility to visualize content supports gaining insights for a deeper understanding, better explanation, and for the development of groundwork for decisions (Liu et al., 2008). In an experiment by Fischer et al. (2002) on the support of visualization in team learning processes, it is outlined that teambuilding is formed by the previously gained knowledge of the individuals to collaboratively shape the team process with different views and approaches, which is defined as collaborative knowledge construction. The experiment shows that content-specific visualization increases individual knowledge structures in team processes (Fischer et al., 2002). These individual knowledge structures are directly linked to SMM. When it comes to virtual collaborative visualization, the external representation is formed via the support of IT, which acts as a mediator between the human and the image (Walny et al., 2011). However, there is no encompassing theory so far describing the effects of virtual collaborative visualization on teamwork (Liu et al., 2008).

9.3.2 Impact of Visualization on Digital Whiteboards

As Lurey and Raisinghani (2001) and Swaab et al. (2002) show, a continuing scientific investigation on appropriate tools to support virtual teams is needed. For example, Maynard and Gilson (2014) advocate that the development of innovative IT for virtual teams would benefit from the investigation of SMM to involve individual adaptation capabilities (Maynard and Gilson, 2014). We focus on visualization that mirrors thoughts and relationships and connections to understand a given content. One measure to visualize content in virtual teams are digital whiteboards (Maynard and Gilson, 2014; Santos et al., 2015; Swaab et al., 2002; Tang et al., 2009). Digital whiteboards are digitized versions of a plain paper that can be used to sketch (complex) thoughts, relationships and ideas to personally gain insights or to explain content to team members (Walny et al., 2011). Whiteboards - if physically or virtually present - differ from plain paper in terms of size to act upon (that influences the possibility to collaborate) or its means of change and modification through its ability to erase content (Ju et al., 2006). The possibility of changing and deleting content of visual representations that has been collected in teams offers the opportunity to find a common ground on specific content through agreements via collaborative visualization (Ju et al., 2006). Past research (Abowd and Mynatt, 2000; Walny et al., 2011; Tang et al., 2009) has shown that the use of whiteboards supports thinking processes, but there is still a lack of research on specific thinking processes. Sketching (on whiteboards) is associated with flexibility and improvisation. Other than in text-based communication, e.g. via email that is rigid, collaborative visualization means moving images, text, data, thoughts, and ideas (Ju et al., 2006). Recent research additionally highlights the effectiveness of digital whiteboards to improve collective mindfulness and subsequently improve collective decision quality (Curtis et al., 2017). Collective mindfulness means that team members mutually contribute to the discussion, align their actions and form a SMM (Weick and Roberts, 1993). With the help of a digital whiteboard, participants were able to integrate new information from other team members better into their mental models and the overall communication patterns among the virtual team members were more effective (Curtis et al., 2017). This makes whiteboards an appropriate tool for the forming phase of a team process in order to create a common image that is a visual representation of collective understanding (Mynatt et al., 1999). Analogue whiteboards have restrictions in form of using markers, sticky notes, and photos (that need to be prepared in advance) on a dedicated surface (Mynatt et al., 1999). Work results on analogue whiteboards are difficult to document (Mynatt et al., 1999). In contrast, digital whiteboards are more flexible and offer the opportunity to add information in form of photos, videos, audios, and text in real-time (depending on the functionality of the offered software). Due to the development of diverse digital whiteboards that can be used freely to some extent, digital visualizations of any content, either personal, individual, or team based have to overcome less barriers and can be used in diverse settings (Ju et al., 2006; Sorapure, 2010). The original task of whiteboards has been transformed from sketching and drawing into visually expressing thoughts with diverse media opportunities on a screen (Ju et al., 2006). The opportunities that digital whiteboards offer for virtual collaborative visualization need further examination. Hence, we aim to analyze the chances of using digital whiteboards in the forming phase of virtual teams, which leads us to conduct an experiment in which we firstly define a contemporary, wicked problem for teams to test our artifact.

9.4 SMM in the Forming Phase of Virtual Team Performance

9.4.1 Shared Mental Models

SMM are dispersed systems, which unite knowledge structures to collaboratively agree upon individual representational conditions via delineated media (Banks and Millward, 2000). SMM are measurable psychological constructs and describe the agglomeration of diverse mental models in a team (Mynatt et al., 1999; Rouse and Morris, 1986). Each individual has an own mental model in order to incorporate the miscellaneous facets a person acts in. Mental models are individual cognitive displays, which directly interact with a person's environment and shape the reaction and interaction in any context (Resick et al., 2010; Rouse and Morris, 1986). Mental models expose the necessities, wishes, and requirements of a person to generally interact in any situation and therefore shape decision making (de Vreede et al., 2012). While mental models refer to an individual level, the construct of mental models is shifted towards a team level. Team Mental Models (TMM) mirror the interrelation of individual cognitive displays that fuse together in order to collaboratively care for occupational duties, such as task and performance of team interaction (Cannon-Bowers et al., 1993; Cannon-Bowers and Salas, 2001; Resick et al., 2010; Rouse and Morris, 1986). Within research on TMM, one area focuses on the similarity of mental models, which is called SMM (Cannon-Bowers et al., 1993; Cannon-Bowers and Salas, 2001; Mohammed et al., 2000; Bittner and Leimeister, 2014; Corvera Charaf et al., 2013; van der Pol et al., 2006). The most common and general approach of SMM refers to a collaborative comprehension of every team member, although individual mental models vary (Klimoski and Mohammed, 1994; Maynard and Gilson, 2014; Santos et al., 2015). This indicates that SMM are an influencing factor for the success of team building and in general for the forming phase of team processes. Furthermore, SMM are measurable constructs that allow the assessment of team processes that are based on cognitive individual concerns, such as satisfaction, and therefore act as an indicator for successful collaboration (Klimoski and Mohammed, 1994; Lim and Klein, 2006). SMM symbolize the individual structures of knowledge of one person to interact collaboratively with other knowledge structures, thus creating a joint course of action in relation to one's environment (de Vreede et al., 2012). These knowledge structures can be divided into two types: task-related and team-related (Johnson et al., 2007). Task-related SMM influence the team performance, as the team members' mental efforts can be allocated due to the reduction of communication demands (Langan-Fox et al., 2004). While prior research (Cannon-Bowers et al., 1993; Mathieu et al., 2000) focused on task-related structures, Johnson et al. (2007) developed a team-related measure, aiming to examine task-independent information about the team's interactions, attitudes and skills. De Vreede et al. (2012) developed advanced categories of SMM knowledge structures, including the following team-related areas:

- knowledge structures on equipment and tools;
- knowledge structures on team task, goal, and performance requirements;
- knowledge about other team members' abilities, knowledge, and skills;
- knowledge about appropriate team interactions.

Past research often concentrated on one of these categories (de Vreede et al., 2012). We follow this approach and focus on the knowledge structure on team task, team goal and performance requirements, since a common comprehension of all team members towards the task, goal and procedure is the foundation of the forming phase of (virtual) teamwork (Mathieu et al., 2000). Therefore, we do not consider the area "knowledge about other team members' abilities, knowledge and skills", as our focus lies on the comprehensive understanding of a wicked problem. Additionally, developing an understanding of each team member's abilities and skills requires more time and the entire process of problem definition and problem solving (Kanawattanachai and Yoo, 2007). This involves the division of labor according to the individual knowledge and skills, which is why we focus on the problem definition phase.

9.4.2 Collaboratively Visualizing Wicked Problems and SMM

Sketching, as it is usually done on (analogue) whiteboards, is a visual examination of relevant content of tasks, therefore acting as a means of communication for other task- and team-relevant people leading to sharing mental models, respectively "shared visions" (Klimoski and Mohammed, 1994, p. 7). Eventually, the ability of individual cognition in specific circumstances has positive effects when interacting in a team, which can be influenced by visualization (Liu et al., 2008). This initial situation directly leads, in terms of virtual teamwork, to the examination of the interaction among humans and computers and the analysis of specific virtual tools that are meant to support specific teamwork affordances (Liu et al., 2008). Summing up, visualization has a positive effect on virtual team performance and consequently on the manifestation of SMM. Nonetheless, the question is whether SMM are able to support virtual teams while handling wicked problems, since the success of solving wicked problems is restricted by the boundaries of cognitive capabilities of individuals and teams (Buchanan, 1992; Liu et al., 2008). Wicked problems challenge the human capacity, e.g. imagination (Liu et al., 2008). It is therefore necessary to develop appropriate tools to support teams - and in our case virtual teams - in the forming phase. Wicked problems are special cases, when it comes to the forming phase of teamwork, since an absolute understanding of every influence and dependency of a wicked problem is not achievable (Buchanan, 1992). The design process and the process of problem solving can be divided into two distinct phases. The first phase comprises the problem definition which "is an analytic sequence in which the designer determines all of the elements of the problem and specifies all of the requirements that a successful design solution must have"(Buchanan, 1992, p. 15). The second phase encompasses problem solving, where the requirements and elements are combined in order to create a solution. Wicked problems have no definitive formulation, which impedes the problem definition phase and leads to difficulties when determining all the elements on a team level. This means that the outcome of the problem definition phase cannot be assessed in order to evaluate whether a Wicked problem was effectively defined. In this study, we focus on the forming phase of a team, where the task and the shared understanding of the task are in focus, which aligns with the problem definition phase. Complex problems, that are easier to solve and have an overlap to wicked problems, have already been recognized in SMM research (Mathieu et al., 2000; Rouse et al., 1992). Complex Problem Solving (CPS) is a process that has been established within the scope of psychology (Funke, 2009), where a sequence of tasks is needed to reach a proposed goal. Challenges within CPS are complex, which indicate three requirements that influence clarification; connectivity, dynamics and no-transparency. Connectivity refers to the interconnectivity of events and aspects, dynamics takes place through changing events and requirements and no-transparency states that given events are not predictable (Funke, 2009). CPS as defined by Funke (2009) inherits major aspects of the characteristics of wicked problems, which leads to the assumption that SMM also positively contribute to wicked problems (Thomas and Bostrom, 2007). CPS has a positive effect on the forming of SMM, since the ability of adaptation is highly demanded in this context. Findings conclude that the forming phase of a problem-solving situation, the process, and the outcome can be improved by allowing people to visualize their thoughts (Blaser et al., 2000; Fischer et al., 2002). As visualizing a mental model can help when expressing complex thoughts (Fischer et al., 2002), one approach to support team-based solving of wicked problems is to achieve SMM by visualization.

9.5 Methodology

The presented theoretical backgrounds on teamwork and team stages, virtual teamwork, virtual visualization, whiteboards, and wicked problems in the context of SMM shape the foundation for our experiment on how to enhance and measure effectiveness in the forming phase of virtual teams. Our research objectives are to test, whether collaborative virtual visualization (on a digital whiteboard) of a wicked problem increases the effectiveness of the team forming phase. In 2015, Santos et al. investigated the relationship between SMM and team effectiveness. Their model states that a high SMM lowers team conflicts, fosters creativity and improves team performance. Next to creativity and team conflicts, their research model involves the testing of team effectiveness, that is built on team performance and team satisfaction. We adapt their research model by measuring the shared understanding of team task and goal, team effectiveness and satisfaction. In order to analyze our propositions, we conduct an experiment and follow the approach of Dennis and Valacich (1999). The experiment requires the development of an artifact (Hevner et al., 2004) based on the above mentioned findings. In the next paragraphs, we provide a detailed derivation of our research propositions, followed by a description of our artifact, the conducted experiment and its results.

9.5.1 Proposition

In contrast to MNT, we follow the assumptions of MST and MRT, which state that richer, personal media that supports the synchronicity of communication processes enhance interaction (Dennis et al., 2008; Dennis et al., 1999; Daft and Lengel, 1986; Kock, 2004). Therefore, we chose a digital whiteboard that supports collaborative and synchronous visualization of the team member's individual mental models. Enhanced interaction and communication thereby allow team members to allocate efforts on the task (Johnson et al., 2007) and share more information. Team interaction, like communication and information sharing then leads to a higher SMM. In addition, as wicked problems have no exact definition, it is difficult to evaluate whether a team effectively defined the problem. Therefore, in order to evaluate whether a team went through a successful problem definition phase, other measures such as the SMM must be taken into account. In this regard, we derive proposition 1:

1. A collaborative virtual visualization tool supports the shared understanding of wicked problems.

According to Santos et al. (2015) a higher level of SMM leads to higher satisfaction of team members. In addition, Thomas and Bostrom (2007) and Swaab et al. (2002) state that properly designed tools lead to higher satisfaction in virtual teamwork. As a higher level of team satisfaction is strongly related to team performance (Costa, 2003; Smith and Barclay, 1997), we derive proposition 2:

2. A collaborative virtual visualization tool increases the level of satisfaction of the team members.

Staples et al. (2002) stated that perceived effectiveness is influenced by the use and functionality of information systems and Santos et al. (2015) reflects on the positive effect of the level of SMM and effectiveness in team performance. From these findings, we conceive proposition 3:

3. A collaborative virtual visualization tool results in a higher level of perceived effectiveness of the team members.

Because of the antecedents virtual teams are confronted with (Kirkman and Mathieu, 2005), and the influence of the concept of visualization and its effects (Fischer et al., 2002; Liu et al., 2008; Ware, 2012), we strive to further analyze how teams structured their teamwork. It is of particular interest, whether the use of a visualization tool leads to better structured interaction. Collaborative problem definition needs structured interaction, in order to reach effective interaction and build a shared understanding (van der Pol et al., 2006), which is why we derive proposition 4:

4. A collaborative virtual visualization tool leads to a better structured teamwork.

Through the key elements of SMM, i.e. knowledge structure of team task, goal and performance requirements, we will be able to analyze meaningful criteria in order to answer our propositions and evaluate our artifact. The interplay and relation between our propositions are visualized in the following figure 1, which shows our derived conceptual research model.

9.5.2 Artifact

Our prototype uses the digital whiteboard Spacedeck[4]. Spacedeck is a software that is based on the innovative Real Time Ideation System, which allows users to collaboratively plan, perform, evaluate and document creative and innovation processes. The digital whiteboard involves specific competencies like drawing freely, inserting text, forms, and multimedia such as audio, video-, and image files. The whiteboard has an intuitive functionality and its collaboration can be performed in real-time with multiple geographically dispersed users and on different

[4]Spacedeck on GitHub, https://github.com/spacedeck/spacedeck-open

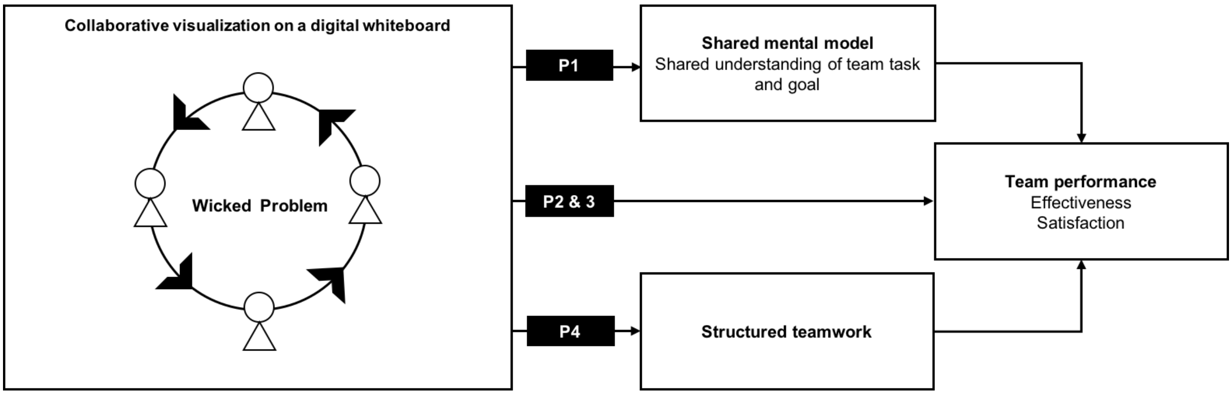

Figure 9.1: Conceptual Framework of Our Propositions

electronic devices. A chat function complements the visual communication. Although several more digital whiteboards are available, we have chosen Spacedeck as it enables direct user integration, which results in an advanced usability. Even though, other digital whiteboards offer more functionalities, such as templates, voting and various export possibilities, we have chosen Spacedeck precisely because of its intuitiveness. This makes it easy to use, clear, understandable and similar to an analogue whiteboard. In addition, we provided visual material of a wicked problem on radioactive waste to the teams, at which we followed the subsequent characteristics of wicked problems (Buchanan, 1992; Funke, 2009):

• Wicked problems have a high number of elements that are relevant to the solution process and are interconnected;

• Wicked problem solutions can be assessed as either good or bad, but there is no right or wrong;

• There is no similar course of action to the solution process;

• Wicked problems are connected to other (complex) problems and there is just one chance for success, and failure is no option.

The visual material of the wicked problem on radioactive waste for the whiteboard template contains 28 elements such as nuclear fission, uranium mining, tailing, nuclear medicine, nuclear reprocessing and interim storage. The arrangement of the visual material on the template does not include a definite formulation or rules on stopping, and it is prepared to resemble a highly non-transparent structure with a variety of connections, influences, different possible goals, and confusing information (Buchanan, 1992; Funke, 2009). The radioactive waste visualization allows for changes and rearrangements to occur. An additional text explanation is included to provide every team with the same information on the task and the proceeding within the experiment. Additionally, we offer a real-time chat that serves as virtual communication medium.

9.5.3 Experiment Structure

Our experiment involved 40 students from undergraduate and graduate programs in the areas of computer science, technology-oriented business administration, engineering, and other technological studies. The age of the participants ranged from 22 to 30 years and the group consisted of 34 male and 6 female participants. All participants were recruited in the course of a lecture, however participation in the experiment was not mandatory. The participants took part in either the experimental group (EG) or control group (CG) and the distribution was blindly and randomly allocated. The distribution of the participants resulted in 10 teams. Consequently, our experiment included 5 experimental teams and 5 control teams with 4 members each. We limited the team size to 4 members since more team members tend to negatively influence the building of SMM (Bossche et al., 2010). The experiment's preparations included the information of the group members concerning the tools to be used, since the participants should not be influenced by uncertainties of functionalities. The group work took place under real conditions, as all participants completed the experiment at home. The participants used their own devices and the communication was restricted to the tool. The experiment began by giving both groups the same written explanation of the wicked problem on radioactive waste, but the teams of the EG were invited to work collaboratively with the digital whiteboard (including a chat function), whereas the teams of the CG were invited to a chat conversation only. The instructions for both groups were identical. Both groups were asked to build a common understanding of the problem, find a common goal (not ideas), and reach a consensus. The teams had a limited time span of 20 minutes to fulfil their task. After completion, all participants received a survey to evaluate the experiment's content. The survey contained questions that directly linked to the level of SMM in respect to perceived effectiveness, satisfaction, and team performance/interaction.

9.5.4 Survey

To evaluate the experiment and to validate our propositions, we conducted a survey on the basis of previously defined constructs from past research (Alrushiedat and Olfman, 2012; Cannon-Bowers and Salas, 2001; Dennis et al., 1996; Johnson et al., 2007; Resick et al., 2010). The 40 participants were asked to rate their perception of the dependent measures ("shared understanding of team task and goals", "satisfaction", "perceived effectiveness", "structured interaction") on a 5-point Likert-scale. The measures are constructed by firstly defining the measure "shared understanding of team task and goals", which contains 21 items and is based on findings from Johnson et al. (2007) and Santos et al. (2015). Johnson et al. (2007) provide a comprehensive construct on how to measure "sharedness" of team-related knowledge. The final construct contains 42 questions, which include five emergent factors of SMM, i.e. communication skills, attitude toward teammates and task, team dynamics and interactions as well as team resources and working environment (Johnson et al., 2007). As stated before, in our research we focus on shared understanding of team tasks and goals. Hence, we constructed the measure "shared understanding of team task and goals" with 21 unweighted items based on items of Johnson et al. (2007) and Santos et al. (2015). As a second step, we determined the measure "satisfaction" that evaluates the level of satisfaction of each participant concerning the collaborative visualization tool. This measure contains seven items grounded on Dennis et al. (1996) and Santos et al. (2015). Thirdly, we defined the measure "perceived effectiveness" of the process, which contains four items based on (Dennis et al., 1996), whereas the item ("How effective was this meeting compared to a face-to-face meeting.") is excluded from the statistical calculations due to its high deviation compared to the other items of the construct. The last measure "structured interaction" indicates how well structured and goal oriented the discussion was and how the communication in the team was perceived. This last measure contains five items based on Alrushiedat and Olfman (2012) and van der Pol et al. (2006). The measure contains two questions, which are excluded from the statistical calculations and are independently treated. All other items used in the measures are weighted equally and are included in the statistical calculations. We calculated the internal consistency with Cronbach's alpha (α) for each measure, to validate that all items measure the same concept (see table 9.1) (Cronbach, 1951; Tavakol and Dennick, 2011). The complete survey with the descriptive statistics can be found in table 11.1 in the appendix .

9.5.5 Results

The results of the survey led to 1480 ratings from 40 participants. Table 9.1 shows the descriptive data of the research results and the Cronbach's alpha for each measure. Due to non-normally distributed data and the fact that Likert-scales were used (ordinal data), we calculated a set of Mann-Whitney U tests to validate our propositions (Gibbons and Chakraborti, 2011; de Winter and Dodou, 2010). The results with a significance level of 5% ($\rho = 0.05$) and r = Cohen's effect size are presented in table 9.2.

Measure	M_{EG}	M_{CG}	SD_{EG}	SD_{CG}	α
Shared understanding of the team task and goal	1.919	3.548	0.837	0.940	.966
Satisfaction	2.050	3.436	0.916	0.969	.899
Perceived effectiveness	2.233	3.700	0.698	0.788	.829
Structured interaction	1.917	3.183	0.743	0.983	.843

Table 9.1: Descriptive Statistics of the Experiment

The Mann-Whitey U tests indicate that each measure in the EG scored statistically significantly better than the CG (see table 9.2). In addition, the results of the survey outline that both groups perceived the discussion to be task oriented and not personal or criticizing ($M_{EG} = 1.450; M_{CG} = 1.800$), but also stated that many explanations were necessary

Measure	U	r	Z	ρ
Shared understanding of the team task and goal	20708	0.662	−9.195	2.2^{e-16}
Satisfaction	3173	0.408	−9.781	2.2^{e-16}
Perceived effectiveness	348	0.465	−7.618	2.14^{e-15}
Structured interaction	617	0.379	−6.207	1.05^{e-10}

Table 9.2: Results of the Mann-Whitney U Tests

during the process ($M_{EG} = 2.400; M_{CG} = 2.250$). However, the study results also show that the virtually supported forming phase was not perceived as effective as face-to-face meetings ($M_{EG} = 3.450; M_{CG} = 4.000$). To deeper understand the relation between satisfaction, perceived effectiveness and the shared understanding of team task and goals we computed a Spearman's rank correlation analysis (r_s = Spearman's rank correlation coefficient). We aimed to find out whether participants that experience higher effectiveness also experience higher shared understanding, and whether higher satisfaction also might lead to higher shared understanding within the group. The computing of the relationship between satisfaction and shared understanding shows that there is a positive correlation between the two variables ($r_s = 0.830, \rho = 3.846e^{-11}$). Overall, there is a strong, positive correlation between satisfaction and shared understanding. Participants who are more satisfied also valuate a higher shared understanding, while participants who are less satisfied valuate a lower shared understanding. In addition, we computed the relationship between perceived effectiveness and shared understanding. There is again a strong, positive correlation between perceived effectiveness and shared understanding ($r_s = 0.823, \rho = 8.178e^{-11}$). Participants that experience higher effectiveness also valuate higher shared understanding. Participants that experience a less effective group interaction also valuate a lower shared understanding. Figure 9.2 shows the scatter plots of both correlations and the division into the EG and CG.

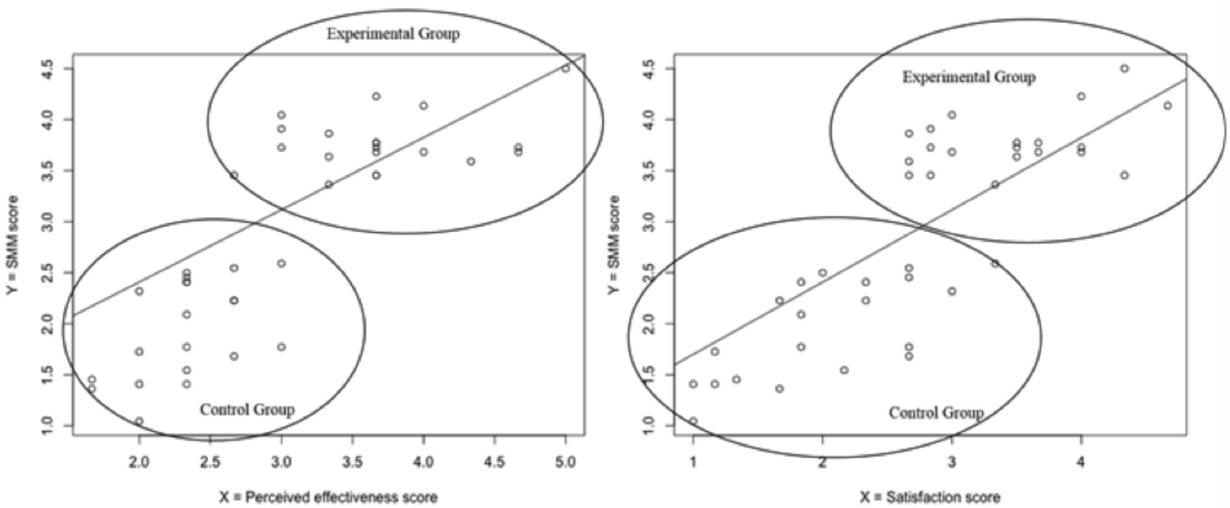

Figure 9.2: Correlation Between SMM and Perceived Effectiveness and SMM and Satisfaction.

Using figure 9.2, we derive that without visualization (CG) a limited degree of SMM, satisfaction and perceived effectiveness is reached, which can be exceled by the support of visualization. Furthermore, the analysis of the chat discussions show that the experimental teams used on average 260 words for written communication in the chat. In contrast, the control teams used on average 514 words to communicate and fulfil their task. Eventually, all experimental teams came to a comprehensive visualization of the wicked problem of radioactive waste that contained every important element of the problem construct.

9.6 Discussion

Our research aims to develop an approach to enhance and measure the effectiveness of the forming phase of virtual teamwork. We tested the effects by implementing a well-designed prototype (reflecting SMM, particularly the knowledge structure team task, goal and performance requirements) in an experiment, which follows the suggestion of Lurey and Raisinghani (2001). Furthermore, on the basis of prior research (Alrushiedat and Olfman, 2012; Dennis et al., 1996; Johnson et al., 2007; Santos et al., 2015; van der Pol et al., 2006), we defined measures to test our propositions. First of all, we can state that our chosen measures serve the human-centred approach of evaluation. The results of the experiment, compared to our propositions, were based on a thorough literature review, which led to the following answers:

1. A collaborative virtual visualization tool supports a shared understanding of wicked problems: In summary, we can outline that in virtual teamwork SMM are formed by the support of visualization and the level of SMM is higher with visualization than without. This finding supports our proposition 1 and is in line with findings stating that appropriate IT for specific environments influences the level of shared comprehension (Lurey and Raisinghani, 2001; Maynard and Gilson, 2014; Liu et al., 2008). The results of our experiment show that the EG had a significantly higher shared understanding of the team task and team goal, which indicates that the comprehension of even a wicked problem can be increased with the opportunity to visualize collaboratively in virtual teams. It furthermore outlines that specific virtual tools enhance the shared understanding of teams.

2. A collaborative virtual visualization tool increases the level of satisfaction of team members: The possibility to visualize collaboratively, although team members are geographically dispersed, results in a higher level of satisfaction compared to virtual team interaction without the possibility of visualization. This finding supports our proposition 2 and is in line with findings that underline the positive effect of visualization and perceived satisfaction in teams (Swaab et al., 2002).

3. A collaborative virtual visualization tool results in a higher level of perceived effectiveness of team members: The comparison of the two groups shows that the EG estimated their level of perceived effectiveness higher than the CG, which validates our proposition 3. This is in line with findings that highlight the effectiveness via visualization to build shared comprehension in team processes (Goldschmidt, 2007). This indicates that an appropriate support for virtual teams to shape their team interaction, in our case visualization, positively contributes to individually perceived performance of the team (Maynard and Gilson, 2014).

4. A collaborative virtual visualization tool leads to a better structured team performance: Since the EG evaluated the team interaction as well structured, our proposition 4 is also validated. This result is in line with findings that outline the positive effect on structured team performance through collaborative understanding (Lim and Klein, 2006). Furthermore, the right support of IT increases the level of structured team performance, opening the possibility to collaboratively visualize on a virtual level.

Our results support the findings from research on MRT (Daft and Lengel, 1986) and MST (Dennis et al., 2008; Dennis et al., 1999) in stating that richer, personal media that allows for synchronicity within communication enhances the communication process. In contrast, our results do not provide definite evidence regarding the MNT. On the one hand, we were able to support the shared understanding, perceived effectiveness and perceived satisfaction with the digital whiteboard. This is in contrast to the MNT, as our artifact can overcome cognitive obstacles that are formed via dispersed communication (Kock, 2004). On the other hand, our experiment shows that the interaction within virtual teams is less effective than the interaction within face-to-face teams, as participants answered that the virtual collaboration was not perceived as effective compared to a face-to-face meeting. This is – according to findings from Warkentin et al. (1997) – due to the functionality and accustoming of team members towards the tool. This indicates that the functionalities of the virtual tool need to be further adapted and developed. By choosing a team size of four participants, we followed the literature on teamwork stating that interaction is impaired in larger teams (Martins et al., 2004; Steiner, 1972; Valacich et al., 1992a). However, the interaction in larger virtual teams can be improved compared to analogue groups, due to different communication mechanisms and functionalities (Gallupe et al., 1992; Link et al., 2016; Valacich et al., 1992a). In contrast to that, the likelihood to reach a SMM decreases in larger teams, as more individual mental models need to merge into one SMM (Jeong and Chi, 2007; Rentsch and Klimoski, 2001). The measures we used in our experiment (Johnson et al., 2007; Santos et al., 2015) that examined the level of SMM were designed and evaluated with teams of 4-5 participants. Further research is needed, to examine whether larger teams might also benefit from a digital whiteboard, as dividing and processing tasks between team members can reduce cognitive load (Kirschner et al., 2009; Link et al., 2016). Furthermore, the costs of recombining information afterwards are lower compared to the division of the information, especially in complex tasks (Kirschner et al., 2009). This trade-off between the positive and negative effects should be measured in order to deeper understand if a digital whiteboard can even support the formation and shared understanding of larger virtual teams. In accordance with past findings (Thomas and Bostrom, 2007), the different usage of chat functions in the experimental and control group reveals that team communication has been adapted towards the possibilities of the offered virtual tool. Since our artifact provides the opportunity of visual communication, the need for written conversation was reduced towards technical support. The research from Curtis et al. (2017) aligns with our findings, as their results show that with the use of a digital whiteboard plus a chat function, a richer interaction and communication was reached compared to teams using solely a chat function. With the help of the digital whiteboard the teams mindfully shared information more effectively (leading to an increased collective mindfulness), instead of just holding multiple monologues. In our results, the chat histories of both groups show that the CG had limited conversations on the wicked problem's interconnections, influences, and structures. This highlights that the used IT in virtual teamwork can have effects on the quality of interaction as predicted by Thomas and Bostrom (2007) and Curtis et al. (2017). According to the MRT, collaborative virtual visualization with a digital whiteboard can therefore be seen as richer media when compared to the sole use of a chat function when dealing with wicked problems. The experiment shows that virtual collaborative visualization tools have positive effects on the level of SMM and therefore affect virtual team performance in presumably any phase of teamwork, if developed in an appropriate manner. To conclude, we can adhere that the level of SMM is evaluated higher when visualization supports virtual team interaction in the forming phase, which reiterates past findings (Curtis et al., 2017; Goldschmidt, 2007). Hence, the results show that SMM act as a promising approach to measure virtual team interaction and evaluate virtual tools, which validates the findings from Thomas and Bostrom (2007) on the relation between SMM and collaboration technology. In summary, we can state that individual factors, such as satisfaction, play a major role in SMM in virtual team performance and in team effectiveness.

9.7 Conclusion and Outlook

Since IT has an impact on the effectiveness of working in geographically dispersed teams, virtual tools for teamwork need to be developed further. The advantages of virtual teamwork require an appropriate embodiment of virtual functionalities that serve the chances as well as the challenges that come with virtual team interaction. This paper started with the examination of (virtual) teams and phases of teamwork and moved on with a discussion of the means of visualization. We presented SMM as an indicator as well as a measurement for our artifact before presenting our experiment in detail. Our research results reveal that the usage of a digital whiteboard - with prearranged visual material on a wicked problem - positively affect team interaction, satisfaction, structure, and understanding, and consequently team performance. The evaluation of our artifact shows that visual communication in virtual teams positively influences the forming of team processes and tasks, which affects the team goal and performance requirements. We further found out that the application of the psychological construct of SMM led to a human-centred evaluation of a virtual tool. The findings of this paper shall initialize future analysis on various teamwork phases, as well as the development of virtual tools, which fit and improve the requirements of virtual teamwork and team members. Our paper has limitations concerning the type of visualization accessible to virtual teams, which was concentrated on whiteboards, disregarding other collaborative virtual tools. Furthermore, the number of participants in the experiment was limited, as well as the level of the multidisciplinary approach of the participants. For future research, we suggest the examination of other knowledge structures of SMM in the context of virtual teamwork as well as the integration of other creative methods to enhance team performance. Additionally, the application of visualizations in other teamwork phases need further investigation as well as the influence of visual communication.

10 Paper 5

One for All and All for One - Towards A Framework for Collaboration Support Systems

Abstract

To reach their goals, companies are on a never-ending search to find new methods for innovation. In order to tackle the complex problems, which cannot be solved by a single person, the implementation of teamwork is assumed to be applicable. With this paper, we propose a framework for Collaboration Support Systems, which aims to enhance team performance. We outline the differences between teams and groups and examine collective processes that on the one hand benefit from additional knowledge and mutual stimulation, but on the other hand are negatively influenced by various cognitive and social factors. With basic principles of collaboration, we seek to tackle the negative effects of team performance and try to further enhance the benefits of collective work. In this context, we analyzed group support systems and unified research and practice of various disciplines (like collaborative problem-solving, collaborative decision making, collaborative creativity and collaborative learning), in order to develop a framework for Collaboration Support Systems. Our paper addresses on-going topics (like anonymity in collaboration systems) and presents design principles for software engineers. Based on a comprehensive literature analysis, we introduce several principles and aspects for collaboration systems that can help to better understand collaboration in teams. However, to thoroughly understand the phenomenon of digital collaboration, further research is needed.

10.1 Introduction and Motivation

Businesses have to survive in branches with a regularly vast number of competitors. To come out on top of the competition, innovative and profitable products and services are needed (Kung and Schmid, 2015; Weerawardena and Mavondo, 2011). The process of developing new products or services is based on the ability to come up with, appraise and further refine new and innovative ideas (Forés and Camisón, 2016; Helpman, 2010; Hennessey and Amabile, 2010; Somech and Drach-Zahavy, 2013). To reach this, businesses are on a never-ending search to find new methods to come up with innovations. In order to tackle the complex problems, which cannot be solved by a single person, the implementation of teamwork is assumed to be applicable (Kozlowski and Bell, 2008). The Internet and digitalization in general provide businesses with the ability to work in a decentralized way. To use this advantage, companies rely on virtual teams (Lipnack and Stamps, 1997; Townsend et al., 1998). Virtual teams communicate, work and collaborate while being geographically and organizationally dispersed, with the help of information technology (Townsend et al., 1998). Teams are considered to be more effective when team members support each other's work with the objective of creating better outcomes. In addition, research shows that team efforts outrun the cumulated individual outcome (Connolly et al., 1993; Nijstad and Stroebe, 2006; Paulus, 2000; Paulus and Nijstad, 2009; Santanen et al., 2000; Santanen et al., 2004). Due to synergies within a group setting, each member is able to exceed their personal abilities. Whether this is in a problem-solving process, decision-making process, or creativity process, the achievement of a group is considered to be more effective. Especially group and team processes benefit from a diverse number of members, due to their individual performance. Every member possesses different abilities and skills, which can lead to better collective outcomes. Besides the additional wisdom and abilities, cognitive and social influences can furthermore enhance collective performance (Paulus, 2000; Pirola-Merlo and Mann, 2004; de Vreede et al., 2012). This influence, however, is not only one of positive nature. A variety of negative group effects appear as well during group performance, like production blocking, evaluation apprehension (fear of criticism), free riding, the sucker effect and social loafing (Diehl and Stroebe, 1991; Karau and Williams, 1993; Kerr, 1983; Kerr and Bruun, 1982; Mullen et al., 1991). These effects impair collective performance, thus leading to inferior outcomes. Research on group creativity and collaborative learning outlines these effects and presents a variety of approaches and principles on how to deal with any negative effects, while still maintaining the positive effects of a team (Resnick et al., 2005; Tinzmann et al., 1990; Voigt et al., 2013a; Voigt and Bergener, 2013). With the rise of information technology, the design and development of group support systems started. Different functionalities helped teams to effectively work together. With electronic brainstorming and the possibility to synchronously communicate, the effect of production blocking, which states that just one person at a time can talk in a face-to-face group process, could be effectively tackled (Barki and Pinsonneault, 2001; Dennis et al., 1999; Nunamaker et al., 1987). The functionality of anonymously contributing in a group process can on the one hand reduce evaluation apprehension, but on the other hand increase social loafing and free-riding (Connolly et al., 1990; Valacich et al., 1992a). Research and practice gradually formed and offered new approaches and principles on collective performance and how information technology can support this process. These approaches include design principles and guidelines on how to design and develop such group support systems (Bawden, 1986; Gabriel et al., 2016; Hilliges et al., 2007; Nunamaker et al., 1987; Resnick et al., 2005; Voigt and Bergener, 2013). Our objective is to unify the literature and practice on group, team and collaborative creativity as well as on collaborative learning. We then apply the results from case studies and research to construct a framework for collective performance with the help of collaborative principles. The framework we propose includes design guidelines aiming to support a collaborative culture and subsequently enhance collective performance. First, we depict the differences between collaboration and cooperation and disclose basic principles for collaboration. In this context, we also highlight the basic characteristics of groups and teams. The next section deals with team composition and the role of diversity and personality for team performance and collaboration. This is followed by an analysis of group, team and collaborative creativity with regard to systems supporting creative collective processes. In addition, we analyze collaborative learning and approaches to improve collaborative learning. With a unified understanding of collaboration processes, we subsequently propose a framework for collaborative team performance and disclose factors that inhibit or enhance collective performance. Our framework includes design guidelines and requirements for Collaboration Support Systems in order to minimize process losses and maximize process gains, to reach an overall effective team performance.

10.2 Collaboration and Cooperation

In current and past research, the terms collaboration and cooperation are often used synonymously. Therefore, we first describe briefly the different concepts of cooperation and collaboration. For a cooperation, at least two partners agree on the contribution and the outcome of the cooperation. A common strategy to reach a goal is not needed for a cooperation. The risk which both partners have to face is the individual's opportunism (Gerosa et al., 2006; Gulati et al., 2012; Hord, 1981; Mattessich and Monsey, 1992). Hord (1981) describes the difference between cooperation and collaboration in a very picturesque way: "(...) dating is a cooperative venture, while marriage is a collaborative one" (Hord, 1981, p. 3). In his description, he refers to the diverse goals people have when dating. In contrast, the goal pursued in a marriage should be the same. Collaboration instead can be explained as the joint effort towards common goals. "Collaboration can occur in any domain where people seek to create value together" (Randrup et al., 2016, p. 900) and is based on a variety of comprehensive principles. The given definition already brings up two main concepts of collaboration, which distinguishes it from cooperation: a common goal and the joint effort of a collective. Having a common goal is the key factor of collaboration and motivates every group member to work together (Wheelan, 2009). In their article "Philosophy of Collaboration", Randrup et al. (2016) describe this as benevolence, where "collaborators should not intentionally work against the attainment of the group goals and should negotiate in good faith to accommodate the private goals that motivate individual member participation in the collaboration." (Randrup et al., 2016, p. 904). In the learning context, the terms collaborative and cooperative are again constantly used synonymously, even if they have different meanings (McInnerney and Roberts, 2004). Both collaborative and cooperative learning methods use social interaction between the learners in the process of knowledge acquirement (Dennen, 2000). In comparison, a traditional learning method mostly occurs with an instructor providing information and printed materials during lectures. In this method, there is almost no shared learning experience as a form of interaction between the learners (McInnerney and Roberts, 2004). Consequently, no additional thoughts or inspirations are stimulated (Bligh, 1998). Dillenbourg et al. (1995) distinguish collaborative learning from cooperative learning by using the contrast between cooperative and collaborative problem solving by Roschelle and Teasley (1995). They describe collaboration as a "mutual engagement of participants in a coordinated effort to solve the problem together" and characterize cooperative learning by saying that "cooperative work is accomplished by the division of labor among participants" (Roschelle and Teasley, 1995, p. 70). It emphasizes the responsibility of each learner for a part of the problem solving (Dillenbourg et al., 1995). More detailed, Dillenbourg (1999) describes that "in collaboration, partners do the work together", whereas in cooperation, partners split the work into sub-tasks, solve them individually and then summarize partial results into a final solution (Dillenbourg et al., 1995, p. 8). Both use interaction within and between learner groups for achieving a common goal while working together. The attainment of this goal leads to happiness and satisfaction for every individual and in addition motivates to collaborate, which encourages individuals to work together and fulfill even personal needs (Briggs et al., 2008). This can be explained by the Yield Shift Theory of Satisfaction, which states that "the more likely people perceive they are to attain their goals, the more positive their satisfaction responses" (Randrup et al., 2016, p. 900). Yield is, directly related to effort, as explained in the Collective Effort Model. The model states, that individuals extend less effort when working on a collective task, as the outcome is not directly related to the individual effort (Briggs et al., 2008; Karau and Williams, 1993). Collaboration however entails the total commitment of every group member. Randrup et al. (2016) describe this as an obligation, where collaborators should deliver sufficient effort (Randrup et al., 2016). That in turn means that no one should withhold any input and everyone should openly and honestly contribute. Reciprocity brings the concept of obligation into the collective nature as it states that if one collaborator extends more effort, the other group members should return the effort when needed (Barczak et al., 2010; Kasper-Fuehrera and Ashkanasy, 2001; Bijlsma and Koopman, 2003; Randrup et al., 2016). Axelrod and Hamilton (1981) describe the reciprocity-concept with the English saying "TIT FOR TAT". This implies, in a collaborative setting, that a favorable behavior of another person is simply mirrored (Axelrod and Hamilton, 1981). Hence, as long as a person can perceive a team member's collaborative behavior, they will likely behave in the same way. This could prevent teamwork problems like social loafing or free-riding, as mentioned above. The very basic principle of "TIT FOR TAT" can be traced back to early philosophy, where it is discussed under the term "golden rule" (Bunnin and Yu, 2007). In summary, we define collaboration as the joint effort towards a common goal, where a collective works together, without the division of labor. In the next section, we will derive various principles of collaboration that are necessary to successfully perform collaboration.

10.3 Principles of Collaboration

Reaching this collaborative culture however, is not as unpretentious as the principles state. Motivating individuals to work together is complex and different in every context. Nevertheless, collaboration works better if different group fundamentals are upheld. One important collaboration principle is trust. It enhances group work in a variety of ways, like increasing the willingness to share knowledge and to devote individual resources (Barczak et al., 2010; Kasper-Fuehrera and Ashkanasy, 2001; Bijlsma and Koopman, 2003; Randrup et al., 2016). "Trust acts as a facilitator and promotes interpersonal relationships prompting people to seek and give help leading to a more collaborative culture." (Barczak et al., 2010, p. 335). Trust is therefore positively linked to group performance and creativity (de Vreede et al., 2012). Trust however, requires and implies mutual respect. Mutual respect occurs when every group member's voice has the same value and when every opinion is considered (Nelson and Cooprider, 1996). In organizations and companies, this entails the establishment of a heterarchic structure. Creating team trust is therefore indispensable. One way to create trust is by group awareness or Team Emotional Intelligence. Team Emotional Intelligence is the "ability of a group to develop a set of norms that manage emotional processes" (Druskat and Wolff, 2001), which facilitates collaboration. Group awareness can be seen as a superordinate concept to Team Emotional Intelligence, as it includes a broader knowledge of information about each team member (Bodemer and Dehler, 2011; Gross et al., 2005). These norms state that every group member is aware of his/her own emotions and of the emotions of the team, which decreases team conflicts, creates better interaction and leads to stronger relationships (Barczak et al., 2010; Druskat and Wolff, 2001). Furthermore, if a higher level of trust is achieved through the concept of Team Emotional Intelligence, team members can concentrate on "[...] creating and discovering rather than defending." (Barczak et al., 2010, p. 332). A high level of Team Emotional Intelligence should therefore lead to a better outcome of the teamwork, through the establishment of a trustful working environment. Another aspect for collaboration is cohesiveness or cohesion. Cohesiveness refers to the perception of a group or a team as one unified force (Lawler et al., 2000). Cohesiveness enhances individual commitment, benevolence and can thus lead to a better collective performance (de Wit et al., 2012; Karau and Williams, 1997). Internal team relations and team bonding additionally reflects cohesiveness and can develop social capital within a team. Social capital then allows the team to better pursue the common goal (Leana and van Buren, 1999; Newell et al., 2004). In summary, table 10.1 shows the principles and concepts that are essential for a successful collaboration and an effective collective performance.

Principle	Sources
Reciprocity	(Barczak et al., 2010; Randrup et al., 2016)
Common goal	(Randrup et al., 2016; Wheelan, 2009)
Trust and mutual respect	(Bijlsma and Koopman, 2003; Kasper-Fuehrera and Ashkanasy, 2001)
Group awareness and Team Emotional Intelligence	(Barczak et al., 2010; Bodemer and Dehler, 2011)
Benevolence and commitment	(Briggs et al., 2008; Gulati et al., 2012; Randrup et al., 2016)
Cohesiveness	(de Wit et al., 2012; Evans and Dion, 2012; Karau and Williams, 1997; Lawler et al., 2000)

Table 10.1: Principles of Collaboration

To further distinguish the necessity for the observance of these principles, we deeper illustrate group and team processes. In the following section, we first depict the differences between groups and teams and disclose cognitive and social influences, which affect collective performance.

10.4 Diversity in Group and Teams

In order to grasp the term collaboration, it is important to distinguish between groups and teams. However, prior research often neglects this difference and uses the terms identically (Hilliges et al., 2007; Hoever et al., 2012; Mamykina et al., 2002; Paulus, 2000; Pirola-Merlo and Mann, 2004; Stockleben et al., 2016). The diverse characteristics of groups and teams are substantial to define rules and principles for a collaboration process. A group can be defined as two or more individuals, who work together in an interdependent relationship to fulfill a specific task (Forsyth, 2014; Paulus, 1989). Groups often occur on their own and do not stand in an organizational setting with specific rules or principles. Thus, groups are loose constructs without a precise period of existence and without an exact beginning and ending. Groups are therefore not specifically formed and do not necessarily follow a common goal, whereas each group member instead works on their individual goal. Teams are groups that are within an organizational setting and have a long-term relationship. Teams are often formed with specific guidelines and rules and work together to reach a common goal (Cohen and Bailey, 1997; Hackman, 1987). These characteristics include different social influences that a team and a group imply. In teams, social influences develop over time and factors like hierarchy and rules shape the type of collaboration. Even so, Paulus et al. (2012) state that collaboration occurs in both, teams and groups. Nonetheless, the basic principles of collaboration vary between groups and teams and have to be applied accordingly (Paulus et al., 2012). Essentially, it can be stated that teams are groups within a specific setting, with defined rules and principles, that follow a common goal and work in a long-term relationship and where specific collaboration principles can develop in a stronger manner. Due to the fact that the terms group and team are used interchangeably in the existing literature, we continue to examine both, research on group and team performance, but will concentrate on team performance within our framework for collaboration processes. Evidence for negative and positive effects regarding the influence of diversity in teams is highly inconsistent (Bowers et al., 2000; Webber and Donahue, 2001; Williams and O'Reilly, 1998). Jehn et al. (1999) showed that informational diversity was positively related to commitment and team performance, whereas apprehended value diversity was negatively related to member satisfaction, team performance and commitment. Demographic diversity was unrelated to group performance and positively related to member satisfaction, commitment, intent to remain and perceived group performance (Jehn et al., 1999). Bunderson and Sutcliffe (2002) found positive as well as negative relationships between performance and team process for different types of informational diversity. Other studies show positive effects of demographic diversity (Simons et al., 1999). Studies report that diversity in values and attitudes may be related to positive outcomes, such as social integration (Harrison et al., 1998; Harrison et al., 2002). However, there are two traditional research perspectives on team diversity and performance (Williams and O'Reilly, 1998): the information/decision-making perspective and the social categorization perspective. The information/decision-making perspective indicates a positive effect of group diversity based on the conviction that diversity will lead to a broader range of task-relevant knowledge, abilities, skills and views from the different members. This might be helpful for working on non-routine problems and could result in more creative team performance as the need of integrating and reconciling diverse perspectives may stimulate divergent thinking (van Knippenberg et al., 2004). According to various studies on the correlation between team performance and demographic diversity, a diverse team leads to improved creativity if it is structured. Long-established and diversified human relationships, along with the existence of diverse information, experiences and technologies also have a positive influence on the output (Pelled et al., 1999). Taylor and Greve (2006) argue that a team can create innovation in a diversified knowledge domain by the combination of its knowledge. McGrath (2001) insists that diversity has a positive effect on the creative manifestation process (exploration and exploitation) particularly for exploring new products, creating new business practices and developing new technologies. Tiwana and McLean (2005) illustrate that a team formed by members with diverse technologies, competencies and knowledge can have significantly improved creativity and performance. In contrast, the social categorization perspective suggests that team members prefer to work with members of similar attitudes and values (Brewer, 1979; Turner et al., 1987). Moreover, homogeneous groups tend to have a more frequent and multi-variant communication, as they share a unified culture and world view due to in-group attachments and shared perceptions (Earley and Mosakowski, 2000). Since homogeneous groups have no critical cultural difficulties during social exchange, they are more likely to be able to create an environment which encourages positive social associations and in-group social contact (Blau, 1977). In accordance with social identity theory, homogeneity increases cooperation and satisfaction while reducing emotional conflicts (Tajfel, 1974; Williams and O'Reilly, 1998). Some studies argue that homogeneous teams can achieve more than a diversified team (Jehn et al., 1999; Riordan and Shore, 1997) , as an extremely diverse team might cause coordination problems leading to fewer achievements (Chae et al., 2015). However, recent perspectives reveal the coexistence of both social/categorical and informational group responses regarding diversity (van Knippenberg et al., 2004). In addition, the social categorization perspective hinders team members to effectively work together due to the lack of similar values, the lack of a unified culture and due to in-group attachments, which however, can be reached with the principles of collaboration. Especially group awareness and Team Emotional Intelligence can be beneficial to enhance communication and create an environment that encourages in-group social contact. In addition, Team Emotional Intelligence can also reduce emotional conflicts. Therefore, with the principles of collaboration, the social categorization perspective can be diminished and a more diverse team should be strived for. Besides different values and attitudes, personality plays an important role for collaborative behavior (Bradley and Hebert, 1997; Lamprecht et al., 2016; Shen et al., 2007). "Personality has a significant influence on group work and a proper constellation of personality types can improve the output of teams significantly" (Lamprecht et al., 2016, p. 131). Thus, individual personality has to be taken into account when composing a team which should collaborate over a long-term period to reach a common goal. In summary, collaboration can highly benefit from a multidisciplinary and diverse team (including different personality types within the team).

10.5 Collaborative Team Process

As mentioned before, collaboration appears in a variety of processes involving collective decision-making, problem solving, learning and creativity. Collective problem-solving and decision-making involves creativity, where the benefits of a team and the interaction between the individuals support the creativity process (Sawyer and DeZutter, 2009) . Research on group creativity has a long tradition in different disciplines like psychology, neurobiology, pedagogy, economics and even information technology (Hennessey and Amabile, 2010) . Studies on group performance and group dynamics identified that the interaction among group members is a major factor which can have an important influence on group performance. This interaction can be a substantial source for creativity (Sawyer and DeZutter, 2009)and additionally foster the extents to which team members have a shared understanding of the team situation and the task (Cannon-Bowers et al., 1993; Santanen et al., 2000; de Vreede et al., 2012). This is explained by the shared mental model, which acts as a mediator between knowledge-sharing and team creativity (de Vreede et al., 2012). In addition, better team performance has been linked to higher levels of mental model similarity (Lim and Klein, 2006; Redlich et al., 2017). Indirect interaction also influences individual creativity and thus group performance. Cognitive and social influence occur during every group process, whereas each group member can be influenced simply by the presence of each other. However, this influence can either impair or enhance group performance. One main factor is production blocking which states that in a group, only one individual can speak at a time (Diehl and Stroebe, 1991). Another effect is evaluation apprehension, which means that individuals hold back their ideas in a group process as they fear a negative evaluation (Connolly et al., 1990; Nunamaker et al., 1996; Shepherd et al., 1995; Valacich et al., 1992b). Two further phenomena, that influence group performance, are free-riding and social loafing. Free-riding states that group members might consider their ideas as less important for the final outcome, causing ideas to be held back (Kerr and Bruun, 1982). Social loafing can be explained as the tendency of individuals to expend less effort when working in a group and even tend to hide within the group (Diehl and Stroebe, 1987; Karau and Williams, 1993). In addition, the integrated model of individual effort on collective tasks or Collective Effort Model (CEM) "suggests that individuals will be willing to exert effort on a collective task only to the degree that they expect their efforts to be instrumental in obtaining valued outcomes" (Karau and Williams, 2001, p. 119). Although many negative group effects exist, advantages such as mutual inspiration, additional wisdom and knowledge, cognitive stimulation and effective evaluation outperform work done individually. Thus, a group creativity process is highly preferred, but needs to be carried out accordingly. Similar enhancing and impairing factors can be observed in the context of collaborative learning. In many lectures, the educator stands in front of the room and the learners sit at desks listening to him/her. This is not suitable for a collaborative learning environment, since it is difficult for people to transfer knowledge (Bennett, 2004). In such an environment, it is important that everyone has the authority to contribute to ideas or concepts. Both learners and instructors are equal participants (Tinzmann et al., 1990). Usually, the stream of knowledge flows only in one direction, namely from the teacher to the students (Tinzmann et al., 1990), but in a collaborative classroom it is necessary that learners share their personal experiences, opinions and knowledge. Therefore, learners and instructors need to come into dialogue and talk. In a collaborative classroom, where authority and knowledge are shared, the instructor should act as a mediator. He/she helps the learners to figure out how to learn. For example, he/she encourages the learners to connect new information to their knowledge (Tinzmann et al., 1990). Diverse perspectives are important for enhancing learning in such a collaborative classroom. For this reason, the experiences and opinions of everyone are relevant. Therefore, it must be ensured that everyone can participate in the discussion, regardless of the content (Tinzmann et al., 1990). In online collaborative learning, these characteristics are also applicable. Primarily, learners acquire knowledge by communicating. That is why it must be assured that there is a possibility for communication sessions (synchronous or asynchronous) and team composition (Olguín et al., 2000). Regardless of whether collaborative learning takes place in the classroom or online, learners benefit from this approach. Laal and Ghodsi (2012) summarized a list of 50 collaborative learning benefits by (Johnson and Johnson, 1989) and (Panitz, 1999) into four categories: social, psychological, academic and assessment. One of the social benefits is the building of a diversity understanding, which illustrates the importance of forming a heterogenic team with diverse skills and knowledge, thus enhancing the group potential. Learners interact with one another, understand their differences and therefore increase their group awareness and team emotional intelligence. Additionally, they find a solution for social problems which may arise (Johnson and Johnson, 1985). Learning communities are built through collaborative learning (Tinto, 1997). Psychological benefits include an improved self-esteem (Johnson et al., 1998). Additional benefits are, sharing doubts, opinions and questions with other learners in order to stimulate a faster learning rate and to promote critical thinking (Bruffee, 1999; Panitz, 1999). Learners are actively involved in the learning process and construct their own knowledge consequently (Hiltz, 1998; Slavin, 1980). Furthermore, collaborative learning enables alternate forms of assessment (Panitz and Panitz, 1999). Despite the benefits of collaborative learning, there are some challenges. One of the most citepd disadvantages of online collaborative learning is the already mentioned free-rider effect (Kerr and Bruun, 1982). In the context of collaborative learning, this effect occurs when "one or more students in the group does little or no work" (Roberts and McInnerney, 2007, p. 261). Another challenge of collaborative learning pose the likely inequalities of students' abilities and effort (Kreijns et al., 2003; Roberts and McInnerney, 2007). This can result in a sucker effect (Kerr and Bruun, 1982), where the sucker must handle most of the work, because other learners of the group perceive him as the most capable (Roberts and McInnerney, 2007) and the more productive group members decrease their effort as the awareness of the free-riders increases (Kreijns et al., 2003). On the one hand, this results in the same behavior as the previously discussed effect of evaluation apprehension, where individuals hold back their knowledge, opinions or ideas to not suffer from criticism or a perceived bad-standing within the team. On the other hand, it increases free-riding and social loafing of group members, who refuse to support non-contributing group members (Kreijns et al., 2003). Because of these challenges and benefits of collaborative learning, a learning environment that can enhance individual commitment, joint effort, trust and respect has to be created. In such a scenario, collaborative learning can succeed. For a successful collaborative learning, it is necessary that learners additionally share common educational goals. In order to construct a framework of collaborative team performance in information systems, we subsequently examine various information systems that support collaborative creativity (and problem-solving) and collaborative learning, as well as collaborative decision-making.

10.6 Group Support Systems

Information technology is omnipresent and has already found a place in the research of group support (Massetti, 1996; Nakakoji, 2005; Seidel et al., 2010; Shneiderman, 2007). In the past, computer-based Group Support System (GSS) were mainly associated with improving decision-making processes or supporting collective problem-solving (Nunamaker et al., 1996; Proctor, 1993; Zigurs and Buckland, 1998). GSS aim to support groups by providing necessary information or offering tools (e.g. shared working space, commenting etc.) to support both, individuals as well as groups. A special form of GSS are Creativity Support Systems (CSS), which are defined as interactive computer-based systems that support the joint creative effort of individuals towards the completion of a task (Nunamaker et al., 1996). However, the concept of CSS is imprecise. Every system that provides, processes or organizes information during a creativity process can be referred to as a part of CSS (Shneiderman, 2007). The scope of CSS is vast, ranging from digital implementations of existing creativity support techniques, systems that are based on the organization and management of the whole idea generation process, up to creativity stimulation software. In the context of learning, GSS are used to collectively solve problems and work on educational theses and whenever collective problem-solving and decision making play an important role for collaborative learning (Hayen et al., 2007; Humphreys and Jones, 2006). Explaining how information systems should be designed to enhance collaboration has led to a number of articles, dealing with different group processes. Various principles and guidelines for designers and developers of IT systems were proposed in order to support team performance (Hilliges et al., 2007; Resnick et al., 2005; Seidel et al., 2010; Voigt and Bergener, 2013). Resnick et al. (2005) propose ten basic design principles for tools to support creativity, which focus on factors that foster team creativity, such as mutual inspiration, exploration and iteration. Even though, they state that they support collaboration in one of their design principles, they do not provide approaches on how to tackle productivity losses due to social-loafing, free-riding or production blocking. The main focus is set on the team composition that enhances team performance, due to diversity and various individual knowledge and skills. Social and psychological factors are only stated briefly and details on actual design principles, which support trust and appropriation, are missing (Resnick et al., 2005). In 2011, Müller-Wienbergen et al. proposed a design theory on how to develop information systems that aim at supporting creative work and problem-solving. They focus on individual support, but state that various principles also apply for group settings. Their requirements focus on knowledge organization and sharing, the support of diverse perspectives, external idea stimulation and especially highlight the support of both divergent and convergent thinking. Even though, these principles apply for group settings, they do not take negative group factors into account and do not provide approaches to tackle these negative social influences (Müller-Wienbergen et al., 2011). Hilliges et al. (2007) used the term of collaborative creativity and designed a brainstorming application, which takes negative social factors like production blocking, evaluation apprehension and social loafing into account. One approach to tackle evaluation apprehension, the fear of criticism, is anonymity. Even though anonymity tends to increase social loafing and free-riding, the benefit of decreasing evaluation apprehensions appears to outweigh its disadvantage, as more ideas and opinions are being shared within a group (Chen et al., 2014; Hilliges et al., 2007). However, Hilliges et al. (2007) "sacrificed the anonymity of group members in favor of the social implications of group awareness and personal communication" in their brainstorming application (Hilliges et al., 2007, p. 138). This should enhance group awareness and subsequently enhance the collaboration within the group. The results show that especially the visibility of social interaction enhances group awareness. However, significant differences between anonymity, the use of the electronic brainstorming application and the paper-based method were not found (Hilliges et al., 2007). In their literature review, Voigt and Bergener (2013) address factors influencing cognitive and social creativity. They take different negative group effects into account and propose an integrated framework for software engineers. Their proposition of an integrated framework for designing group creativity support systems includes 13 design principles, which can be grouped into principles that support positive group creativity effects and principles that tackle the negative group effects. Principles of the first category are, for example, a shared idea space to enhance mutual inspiration and the support of synchronous and asynchronous communication. To tackle negative group creativity effects, they propose principles like anonymity, social comparison, trace decisions and the facilitation of comparison (Voigt and Bergener, 2013). By scrutinizing the literature on collaborative learning and collaborative creativity, we identified substantial requirements for collaborative performance, which we subsequently adjust to the principles of collaboration in order to construct a framework for Collaboration Support Systems. In the following section, we disclose our approach and formulate various design guidelines to maximize collaborative performance.

10.7 Framework for Collaboration Support Systems

After giving an overview of the principles that have to be upheld to create a collaborative work environment, we now deduce specific design guidelines for CoSS. In order to enhance a group's outcome and respectively enhance the quality of the group outcome, we have to define how the group performance is influenced by different facilitators and inhibitors. The actual group performance can be described with a simple equation (Hackman and Morris, 1975):

```
AGP = GP - PL + PG
AGP: Actual Group Performance,
GP: Group Potential,
PL: Process Loss,
PG: Process Gain
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We adapt this equation and adjust it to collaboration processes within teams, as we constitute that collaboration works best in long-term teams with a defined structure. Our proposed equation is defined as followed:

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ACP = TP - PL + PG
ACP: Actual Collaborative Performance,
TP: Team Potential,
PL: Process Loss,
PG: Process Gain
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Following the theory of Hackman and Morris (1975), one has to ensure that a potential system increases process gains and team potential, while decreasing process losses, in order to increase the overall collaborative performance. To define specific design guidelines, we first summarize the findings of the previous sections on collaborative creativity and collaborative learning and propose according process gains and processes losses that occur during collective performance. In the very beginning, it is advisable to take a look at the team potential, because as the equation states, the process itself can only influence the team potential. In order to have a high team performance, one has to start with a good team. This can be done with heterogeneous teams that cover many abilities, support divergent and convergent thinking. Diversity can be defined as "differences between individuals on any attribute that may lead to the perception that another person is different from self" (van Knippenberg et al., 2004, p. 1008). In general, diversity could refer to any possible dimension of differences, but in practice diversity research has its focus on differences in age, gender, ethnicity, educational background, tenure and functional background (Williams and O'Reilly, 1998; Milliken and Martins, 1996). Apart from that, some perspectives argue that it is also important to consider differences like personality, attitudes and values (Bowers et al., 2000; Jehn et al., 1999; Harrison et al., 1998). An adequate team composition with regard to personality types can lead to better decision-making processes, higher creative performance and subsequently to a significantly improvement of the overall team performance (Bradley and Hebert, 1997; Chamorro-Premuzic and Reichenbacher, 2008; Shen et al., 2007; Stumpf and Dunbar, 1991; Volkema and Gorman, 1998). Recent research suggests that the analysis of the team members' written texts can give valuable insights on those differences, in order to form the most heterogeneous group possible (Lamprecht et al., 2016). This is achieved through analyzing the provided texts with text mining algorithms. The resulting personality traits are used to form teams with a high potential. The described collaboration recommender system would not be possible in offline teams due to the tremendous effort the team building process would require. All in all, it is essential to compose a team with a high diversity considering individual personality. In addition, it is inevitable to set common goals, define a team structure and reach an agreement on shared values to minder the social categorization perspective and foster team performance. Process gains of collaborative problem-solving, creativity and learning concur with mutual inspiration, additional thoughts, knowledge, doubts and opinions, diverse cognitive abilities (like the ability to form associations) and the ability to perform mental leaps. On a social level, influences like mutual motivation, the encouragement to share different thoughts and knowledge and reciprocity enhance group performance and thus can be grouped into process gains. Process losses are production blocking, evaluation apprehension, the sucker effect, social loafing, free-riding, a reduced individual effort on collective tasks, conformity and peer pressure. In order to maximize the group performance with the help of a CoSS, we have to define various design guidelines, which enhance process gains and minimize process losses.

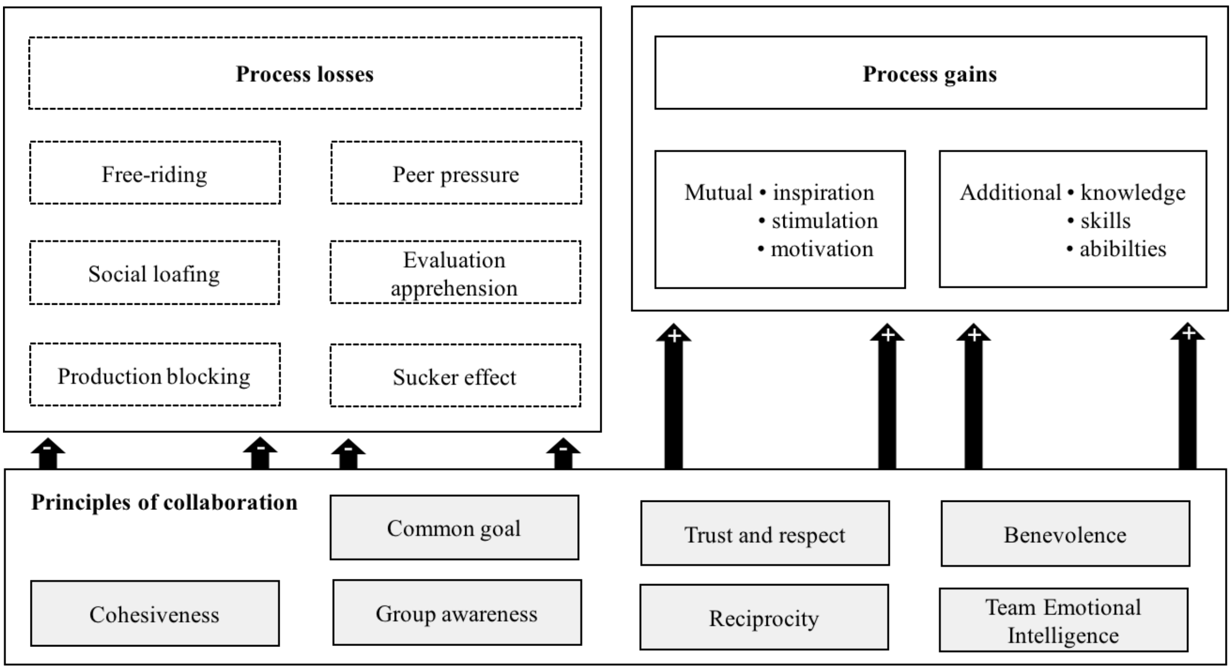

Figure 10.1: Principles of Collaboration to Reduce Process Losses and Enhance Process Gains

Design principles that enhance processes like mutual inspiration, cognitive stimulation and knowledge sharing are, among other things, a shared working space, synchronous and asynchronous communication, different working modes, organization, evaluation and selection of ideas, thoughts and information (Finke et al., 1996; Resnick et al., 2005; Seidel et al., 2010; Stockleben et al., 2016; Voigt and Bergener, 2013). A shared workspace provides individuals with the functionality to express individual thoughts and ideas, as well as with the possibility to understand the thoughts of the other group members. Different working modes like synchronous and asynchronous communication are used to foster the joint effort and to reach a common goal. Asynchronous communication tackles the production blocking effect, as it creates the possibility to share thoughts and contribute simultaneously. Thus, individuals can contribute even when other content is provided. The concept of anchored discussion supports collective working with a tool, where comments can be tied to one aspect of a comprehensive work. Anchored discussion has already been successfully implemented in idea generation (Link et al., 2016) and e-learning (Alrushiedat and Olfman, 2012) With anchored discussion, individuals can work on a collective idea or work and concentrate on different aspects, without forgetting the big picture. This has been identified to reduce cognitive load, which especially appears when working in a group (Link et al., 2016). Voting and rating functionalities offer the possibility to rate and evaluate generated ideas, or learning content, individually and within a group (Panitz and Panitz, 1999; Voigt and Bergener, 2013). Hence, individuals are provided with the possibility to quantitatively contribute their thoughts and opinions to complement other team members' contributions, allowing for the common work to be shaped and improved. By rating different aspects, the work can be improved overall or the selection of the best content can be emphasized. Furthermore, the learning effect can be improved and the individual knowledge can be enhanced (Hiltz, 1998; Slavin, 1980). To tackle the negative group effects, various researches have already devised different approaches and design principles. One feature, is the support of anonymous contributions to tackle the effect of evaluation apprehension, as group members are more willing to contribute when they do not feel any fear of negative evaluation. Especially in groups, anonymity has advantages, such as group members not fearing criticism when they contribute to group work (Jessup et al., 1990; Nunamaker et al., 1991). This effect can be observed mainly in the early stages of ideation and team work, where evaluation apprehension is strong (Connolly et al., 1993). Individuals withhold unfinished and early thoughts, as they fear being misunderstood and that early thoughts may take a turn. In the context of learning, anonymity has the same effect, as it can tackle evaluation apprehension, can lower anxiety in learning groups and can enhance writing productivity, equity and participation (Berge and Collins, 1995; Chester and Gwynne, 1998; Kallookaran and Robra-Bissantz, 2016; McComb, 1994; Miyazoe and Anderson, 2011). Though, many studies support this feature, research has also shown that anonymity can have a negative effect, since it invokes social loafing and free-riding (Connolly et al., 1993; Jessup et al., 1990; Valacich et al., 1992a; Voigt et al., 2013a). Karau and Williams

(1993) additionally state that providing performance standards and cohesiveness within a team additionally tackles social loafing. In addition, studies have shown that anonymity decreases social interaction, involvement and participation (Kreijns et al., 2003). Therefore, we state that anonymity is irreconcilable with the principles of collaboration, as collaboration aims to reach the opposite of what anonymity does: group understanding, group awareness and team emotional intelligence. This requires that everyone knows every other team member. This entails, not only knowing the name and the job position, but also being aware of emotional, social and private information. In this context, the difference between a group and a team setting is important. Nevertheless, anonymity can have a positive impact. The use of anonymity is especially relevant within groups, where individuals work together without particular rules and in a short-term period. For teams, which involve specific rules and follow a structure, we declare anonymity to be counterproductive. Walther (1997) states that a team that has a long-term relationship focuses on unity and that teams, where individuals are working with people who they perceive as friends experience a higher sense of commitment and loyalty. This so-called social facilitation leads to a higher group awareness and increases the effectiveness of collaborative performance. Therefore, in collaboration, group awareness, team emotional intelligence and trust have to be built up, within a long-term process. In a setting where collaborators can contribute anonymously, these essential principles cannot be developed. Thus, we oppose the functionality of anonymity within CoSS. Instead, the opposite of anonymity has to be reached. Hence, we suggest the integration of social media functionalities, like social profiles, user integration and networking and especially the communication and interaction alongside (and temporally separated) from the actual task to build trust and respect (Golbeck, 2009; Ziegler and Golbeck, 2007). This is also supported by Kreijns et al. (2003), who propose the support of social interaction within the non-task contexts. These interactions "show an abundant exchange of socio-emotional and affective information contributing to impression formation, creation of social relationships, group cohesion and a sense of community" (Kreijns et al., 2003, p. 344). Although, building trust and mutual respect is a long-term achievement, it is inevitable to interact with known individuals from the beginning of the team formation. Before starting a collaborative task, it is important to identify and set the common group goal and to foster the understanding of the task. Creating a shared understanding of the task is important to build an effective shared mental model, which is a requirement for an effective collaborative process (Johnson et al., 2007; Thomas and Bostrom, 2007; de Vreede et al., 2012). This, however, does not mean that every team member should have the same idea on how to solve a given task, rather to build a shared understanding of what the actual problem is. In order to establish a base for happiness and satisfaction, it is furthermore important to set achievable goals. Additionally, the common goal and task should be perceived as valuable, to reduce individual social loafing (Karau and Williams, 1993). Karau and Williams (1993) additionally state that social loafing can be reduced and that individuals are willing to compensate for team members' poor performance, when the task is meaningful, which tackles the sucker effect. Thus, we propose a comprehensive initial stage, before the actual collaboration, where the team sets one or more common goals and fosters the shared understanding of the task. In addition to that, sharing information about personal skills and knowledge enhances Team Emotional Intelligence (Barczak et al., 2010), fosters trust and enhances creativity (de Vreede et al., 2012). Other design principles, which should tackle social loafing and free-riding, are the support of session histories, trace contributions and the facilitation of individual comparison. In order to balance group members' contribution and to prevent group members from social loafing and free-riding, a comparison of each individual's contribution should be possible. A session history should provide information about the activities of every team member. This should facilitate the comparison between group members and expose free-riders, who do not participate enough in relation to the group effort (Kerr and Bruun, 1982; Voigt and Bergener, 2013). Even though tracing contributions and comparing the inputs of each team member can tackle social loafing and free-riding, it can also lead to competition and peer pressure. Collaboration, however, relies on reciprocity, respect and transparency, where each group member has an individual commitment towards the group goal. This obligation is fostered by the commitment to reach the goal and produces happiness and satisfaction, if the goal is instrumental to a private goal. Karau and Williams (1993) support this claim and state that individual contributions are unique and valuable to the team outcome, which decreases social loafing and increases cohesiveness (Karau and Williams, 1993). In addition, it ensures that no team member withholds any information that can affect the process (Randrup et al., 2016). This also means that in a reciprocal team, each member is valuable and his/her knowledge and skills are important for the team goal. An appropriate group setting and a reciprocal collaborative culture can therefore minimize the sucker effect. Thus, we propose that tracing and tracking of contributions is not reasonable, nor is the comparison of individual input. Instead, it is important to strive for reciprocity and commitment, which is again achievable by common goals, happiness and satisfaction, personal yield and respect. In favor of the Yield Shift Theory, it is also important that individual goals are set and linked to the common goal. Accordingly, setting a common goal within an initial stage, before the actual team performance, is essential. Setting the common goal within a collaborative setting can ensure that individuals can link the common goal with an individual goal, to achieve a personal yield, which leads to happiness and satisfaction when reached. Figure 2 shows an overview of our proposed framework for CoSS, including design principles to decrease process losses and increase gains in order to maximize collaborative performance.

In order to effectively enhance collaborative performance, it must be ensured that every team member follows the basic principles of collaboration. This, however, cannot only be reached by specific design principles and CoSS, but has to be part of the companies', schools' or universities' culture where collaborative performance is required. Thus, managers of companies have to foster collaborative principles on a long-term period to strengthen the understanding

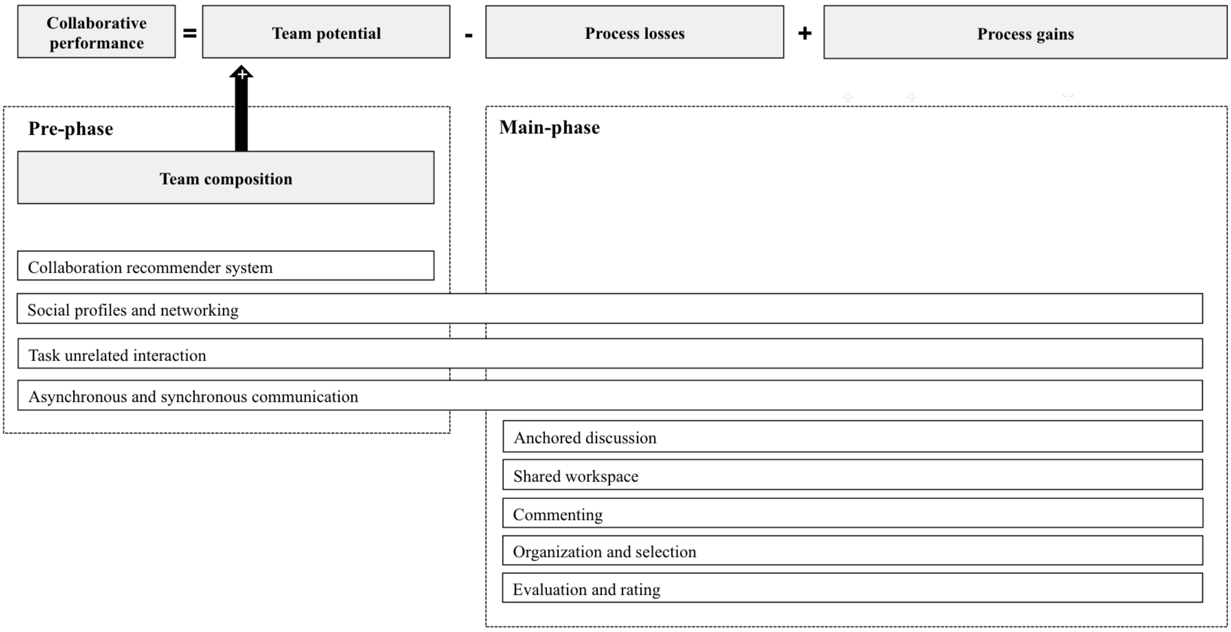

Figure 10.2: Framework and Design Principles for CoSS

and the need of a collaborative culture. Additionally, our design principles require individual implementation, since each and every CoSS is designed differently, aims for different goals and involves different individuals. For these reasons, we intent to reach out to software designers and companies to implement and apply the principles in our framework and for researchers to further study the effectiveness of our framework.

10.8 Conclusion and Outlook

We have set the goal for ourselves to further understand the processes of group and team performance, to identify principles of collaboration and to subsequently unify the research and practice of collaborative problem-solving, decision making, creativity and learning in order to propose a framework for computer-based systems, so that these processes can be effectively supported. By analyzing design principles for Group Support Systems, we distinguished that several of these principles conflict with the basic principles of collaboration. Thus, we disclosed new design principles and adapted them with the aim to enhance collaborative performance. Collaboration can be strengthened by tackling negative team effects, which are caused by cognitive and social influence. In addition, our proposed design principles aim to support factors that improve team processes. Even so, we identified a variety of principles for collaboration and design. We propose to further research collective processes and especially consider other disciplines that require collective performance. This could lead to more specific design principles. In addition, more case studies on actual CoSS and GSS could reveal insights on the long-term usage of computer-based systems and could further expand the knowledge in this field. Furthermore, new technologies, which can support collective processes and learning, are increasing and have to be taken into account. Virtual reality is one promising technology, which has already been identified as an effective tool to support individual learning (Salzman et al., 1999). Innovative approaches exist, which can enhance the immersion of face-to-face learning without being present in a classic learning environment (Huttner and Robra-Bissantz, 2016). Another rising technology is mobile and ubiquitous computing, which allow for new types of learning experiences (Kallookaran and Robra-Bissantz, 2016; Riconscente, 2013). Learning approaches with mobile applications have already successfully improved individual learning (Riconscente, 2013) and collective learning to the same extent (Kallookaran and Robra-Bissantz, 2017). A major factor for collaboration is motivation, which continues to be a challenging aspect in collective performance. Even though our approach aims to enhance individual motivation and subsequently team motivation, other approaches exist. One approach is gamification, which comprises the implementation of game elements into serious context (Morschheuser et al., 2017). Gamification includes elements such as comparison and individual ranking in order to motivate and upgrade participation, which we identified as counterproductive in a collaborative setting. Further research could deepen the understanding and relationship between collaboration and gamification and clarify whether gamification is applicable in the context of collaboration. Besides motivation, it is furthermore important that the observance of the basic principles of collaboration is ensured. Especially benevolence is important for successful collaboration, which is complex to reach in a group setting with specific design principles. Although collaboration is complex and many factors should be taken into account, we think that we have built a first approach on a framework to support collaboration and leave it open for other research and practitioners to further develop our framework for collaboration support systems.

11 General Conclusion

The importance of creativity for the arts, sciences or business as noted by Teresa Amabile is time-independent and omnipresent (Amabile, 1996; Runco, 2004). Creativity as an individual ability becomes a beneficial resource for existing companies or start-ups, that especially unleashes its potential when fostered within groups or teams. The support of creativity has a long tradition, starting with creativity techniques like Brainstorming (Osborn, 1953), to more than 100 existing and applied creativity techniques (VanGundy, 2008). With the help of IT, creativity support can be carried out with computers (e.g. software and hardware). When IT supports the user or users (i.e. individual, group or team) within creativity-intensive tasks, so-called CSS use specific algorithms and functions to enhance creativity (Shneiderman, 2007). With a systematic literature review (see chapter 8), existing CSS were analyzed considering their IT support and collaboration features. The review revealed the absence of active IT support within CSS and the disregard of collaboration principles within GCSS. Overall 56 CSS were analyzed according to their degree of IT support and their collaboration functions. Additionally, five theses that were supervised by the author revealed current state-of-the-art innovation and idea management software and processes within companies. Current CSS solely focus on the organization and management of ideas, without actively contributing to the creativity process. IT therefore takes on a passive role without using its full potential of actively contributing to the creativity process. Additionally, CSS that focus on groups or teams neglect specific collaboration principles, thus not supporting collaborative creativity. Collaborative creativity, when individuals creatively work towards a common goal, is most effective when specific principles are adhered. This identified gap accordingly led to the research question, how IS should be designed to make use of active IT and how collaborative creativity can be supported. This research question contains two main objectives, that are: the use of active IT and the implementation of collaboration principles within CSS, which were tackled with a DSR approach by the author. Within this DSR approach 25 articles were published, covering general creativity support, the use of active IT within CSS and collaborative creativity. The overall DSR approach was an iterative process, where artifacts and research results were presented and successively developed and enhanced. The following section summarizes the results of the conducted research regarding the two objectives. The entire research contribution of the author, with all studies carried out and published, will be presented. All articles which are listed in chapter 1, i.e. also those which are not directly included in this dissertation, are summarized. Among other things, this should explain the evolutionary and iterative approach of the author's research endeavour and show how the entire research is positioned in the research discourse.

11.1 Summary of the Results and Contributions

The relevance of creativity support and especially the benefits of using IT for the support of creativity-intensive processes was covered within the papers 6, 9, 10, 11, 12, 14, 16, 17, 19, 22 and 24. With a systematic literature review, the relevance of the situation and context of a user was examined and possible creativity supporting mechanisms were identified and published in paper 16. The importance of supporting users within their situation was also covered with paper 24. Exploratory studies with entrepreneurs revealed that creativity support is a commonly neglected topic for start-ups. Paper 22, paper 17 and paper 12 showed that the support of creativity and CSS are not common in entrepreneurship. However, especially active IT can support the generation of new ideas, leading to possible new business models as covered in paper 2. Design Thinking, as a interdisciplinary and creativity focused approach, was covered by the papers 14, 11, 6 and 10. The results indicate that IT can be used to support Design Thinking and that creativity and collaboration can be overall enhanced. First evidence was reported that creative abilities are related to personality traits, which can help with the composition of a team. Paper 9 reports first findings on this issue. In summary, the author contributed with results from three experimental studies, one case study, two exploratory studies and one systematic literature review leading to design guidelines (level 2 artifact) to the body of knowledge. Figure 11.1 summarizes the findings (excluding research in progress articles) from studies covering general creativity support aspects.

Designing and implementing IT that actively contributes to creativity-intensive processes requires novel approaches and algorithms. A novel approach that was used to actively support creativity, is an information retrieval algorithm that uses social media content to stimulate creativity. Paper 25 presents this approach on using active IT to generate possible idea stimulating content. Paper 1 further enhances this approach and additionally provides research results on a conducted experiment that shows the benefits of such support. The results provide first evidence that the use of active IT can benefit creativity. With paper 21 and paper 2 a similar information retrieval algorithm was used to stimulate creativity. This algorithm however uses lexical databases to generate new content that can spark the generation of previously undiscovered thoughts. Within an experiment, the benefits of additionally generated questions for the creativity process was proven. Other approaches, using active IT are covered within paper 13 and paper 7, where AI is used to facilitate creativity processes. The main contributions are a novel artifact and design guidelines for virtual moderators of creativity processes. In summary, the author contributed four level one artifacts and one level two artifact, that tackle objective one. Furthermore, two conducted experiments evaluated the applicability of two of the artifacts. Figure 11.2 provides an overview of the main contributions regarding objective one.

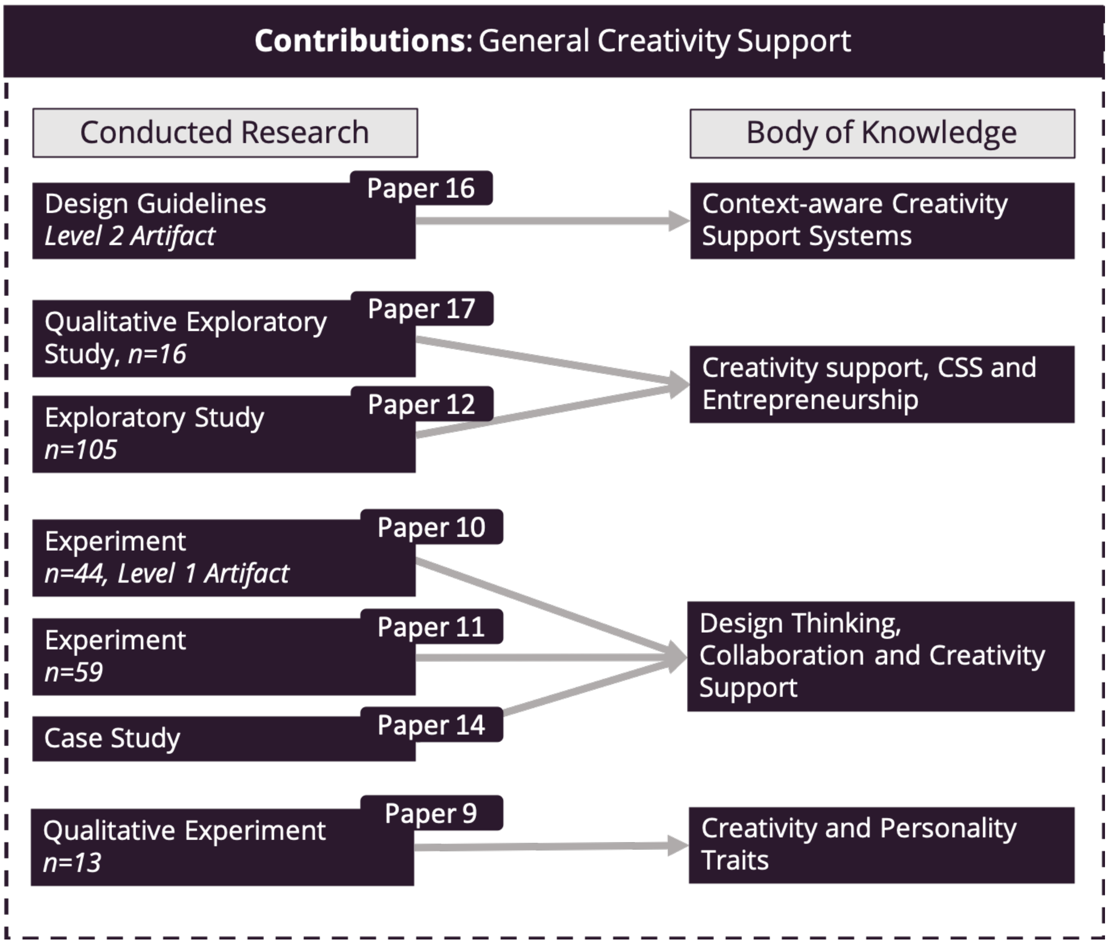

Figure 11.1: Contributions: General Creativity Support

Group creativity comes with a number of benefits, but also negative effects. Current CSS use simple functions, like a chat, where users can communicate with each other. Collaboration principles, as derived in chapter 2, are mainly neglected in current GCSS. Established design principles and frameworks for GCSS (Voigt and Bergener, 2013; Resnick et al., 2005) provide guidance for effective support of group creativity support, addressing process losses like production blocking and social loafing, but still neglect basic principles of collaboration. The conducted literature review additionally showed the disregard of the collaboration principles within existing CSS, leading to objective two. The author tackled objective two with the papers 1, 2, 7, 13, 21 and 25. As collaboration encompasses a variety of mechanisms and principles, a selective and gradual approach was conducted. After gathering various important aspects of collaboration, Shared Mental Models were identified to be crucial for collaboration, leading to the research presented within paper 23 and paper 3. With the feature Anchored Discussion, the SMM of a group was supposed to be supported. In doing so, the improved SMM should lead to an overall improved collaboration and thus more creative groups. The experimental study however revealed that using AD did not improve the SMM, nor did it improve creativity. The

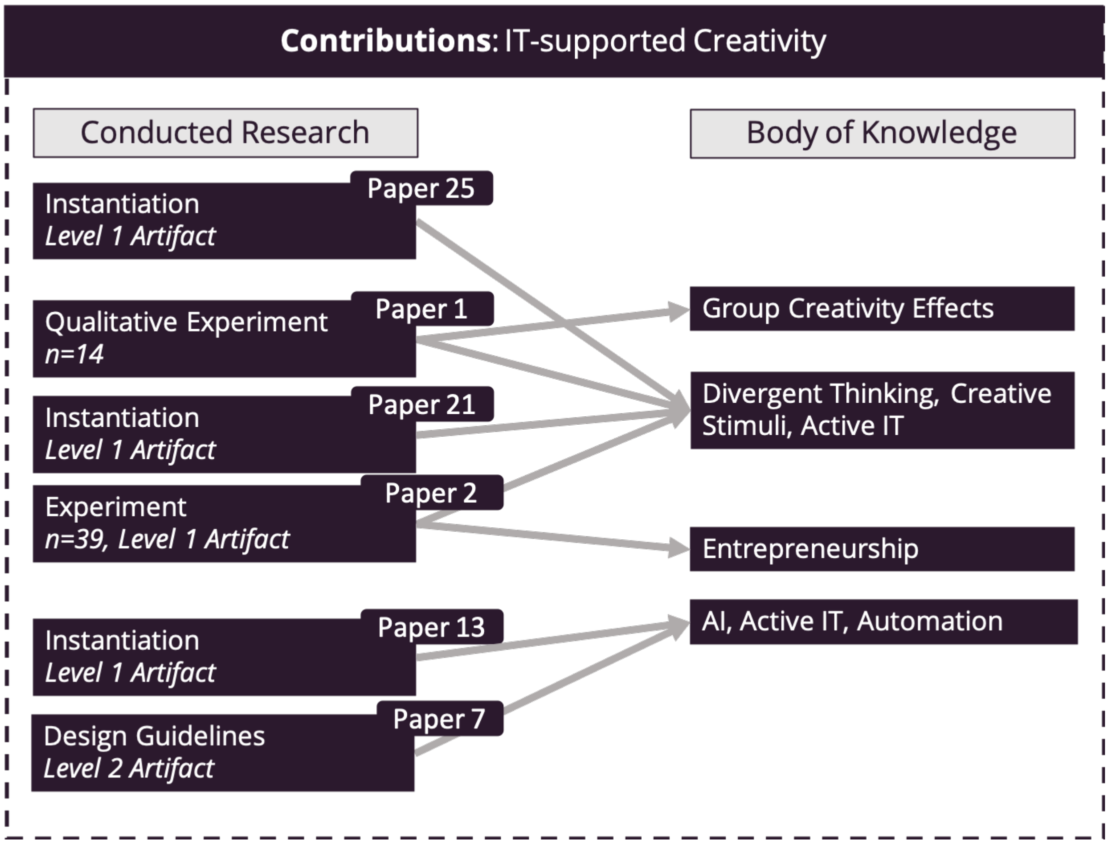

Figure 11.2: Contributions: IT-supported Creativity

results only showed, that groups using AD were able to have a more structured interaction. These results indicate that AD, which can be seen as a division of labour, where a group is divided into individuals working on different aspects on an idea, can not lead to an enhanced SMM. Therefore it is not an applicable mechanism for collaborative creativity, as it is not helpful to split the idea that a group is working on, but rather work together on the whole idea. Following the approach of supporting SMM, paper 15 and paper 4 report the results of an experiment that used visualization and a digital whiteboard to support the shared understanding of a group. The results proved that the SMM could be enhanced with a digital whiteboard leading to a better team formation (i.e. the forming phase (Tuckman and Jensen, 1977)), proving that using a digital whiteboard is a mechanism that can be used to support SMM and thus collaborative creativity. Another aspect of collaboration is TEI, that was addressed with a prototype in paper 8. The prototype uses a virtual reality and other techniques to enhance the TEI and an improved team formation. Paper 20 additionally emphasizes the importance of the forming phase for an effective collaborative creativity, by introducing an artifact (MaKey MaKey[5]) and the mechanism of priming and interaction prior to a creativity-intensive process to improve collaborative creativity. The results of the conducted experiment show that previous interaction and priming can enhance collaborative creativity. Paper 5 synthesizes these findings

[5]The MaKey MaKey invention tool kit contains a circuit board, alligator clips and USB cables, which allows people to connect objects to computers

and, with the help of a literature review, constructs a framework for Collaboration Support Systems. This framework depicts the important principles of collaboration and proposes design guidelines and functions to support collaborative creativity. In summary, the author contributed four level one artifacts, one level two artifact, the results of five experiments and a systematic literature review to tackle objective two. Figure 11.3 gives an overview of the contributions regarding objective two.

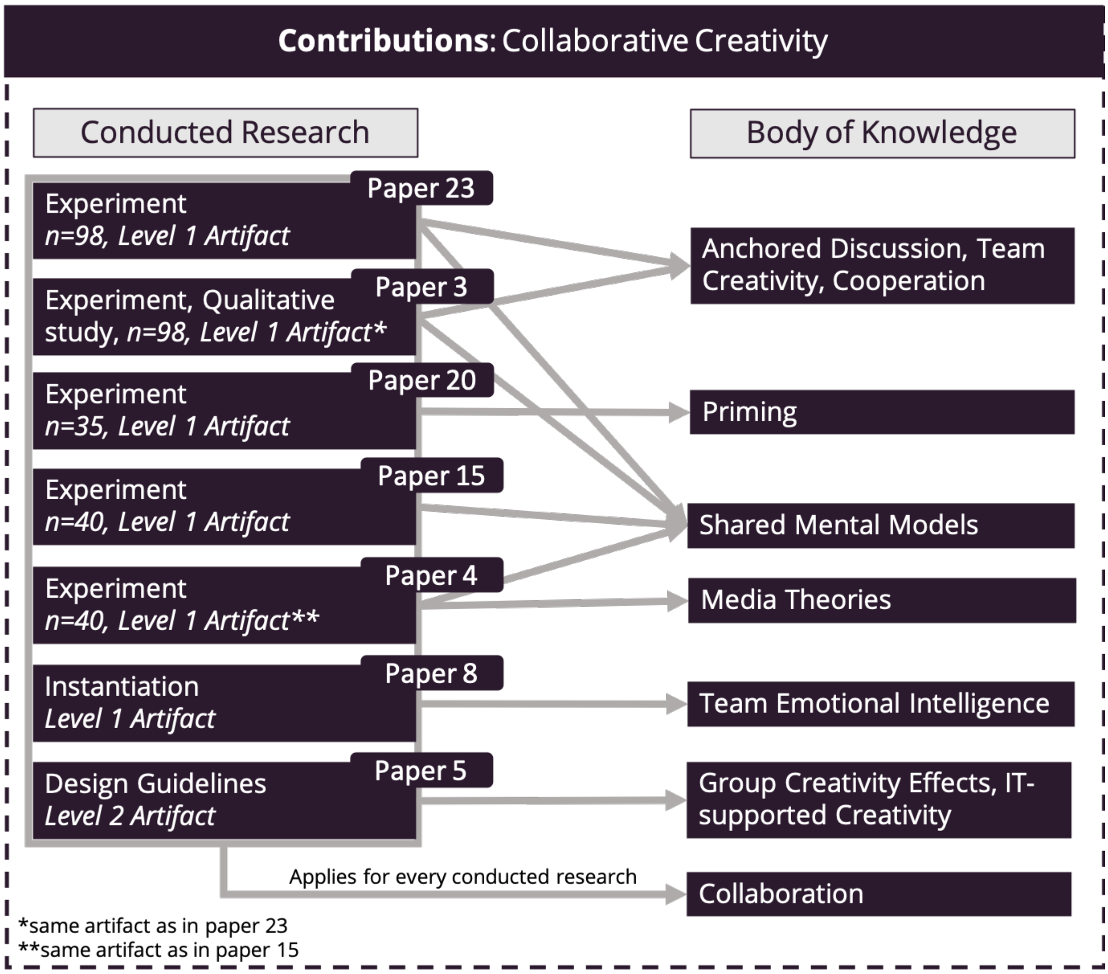

Figure 11.3: Contributions: Collaborative Creativity

In conclusion, the author contributed with a number of artifacts, systematic literature reviews, exploratory studies and results of conducted experiments to the defined objectives. The results provide evidence that the usage of active IT is highly beneficial for creativity-intensive processes and that the adherence of the collaboration principles is necessary for an effective collaborative creativity. In this dissertation, the five most relevant publications were integrated, which on the one hand represent a cross-section of the author's entire research, but on the other hand also present the most relevant research results in the form of developed artifacts, empirical studies and proposed design guidelines. However, results also indicate that the design and implementation of a CSS depends on a variety of factors, e.g. the nature of the task, the phase of the process and the process itself, the overall context and the number of involved people (individual or group). Therefore, a clear answer to the question of how a CSS should be designed is not possible as it depends on a number of factors and is subject to the designer's decisions. Nonetheless, it is important to make use of active IT and support the adherence of the collaboration principles to successfully support creativity.

11.2 Limitations and Implications for Research and Practice

The contributions come with various implications for both, research and practice. First, the results of the conducted experiments contribute to existing theories on creative stimuli, divergent thinking and idea generation in general. Especially, the additional benefits due to the automatically generated content and its creativity stimulation, provide insights on how IT can be used to support creativity. In line with existing theories (Howard et al., 2010; Knoll and Horton, 2010; Santanen et al., 2003; Hender et al., 2002), users generated more ideas, more diverse ideas and enhanced ideas. The results of the conducted studies show, that IT is capable to provide creative stimuli automatically and improve idea generation, which is usually generated by creativity facilitators or moderators (Knoll et al., 2015; Santanen et al., 2003). This contributes to the body of knowledge on creative stimuli and CSS. With the exploratory studies on creativity and entrepreneurship, the specific characteristics and requirements of creativity support for entrepreneurs were disclosed. Existing theories already depicted the importance of creativity for entrepreneurship (Ward, 2004; Zhou, 2008; Gielnik, 2013; DeTienne and Chandler, 2004; Ames and Runco, 2005). The exploratory studies further illustrated the importance of divergent thinking, opportunity recognition and especially creativity support and CSS for the early stages of entrepreneurial activities. This implicates that creativity support and CSS in entrepreneurship differs in substantial ways from creativity support in established companies, thus contributing to theories on creativity and entrepreneurship. The conducted research on collaborative creativity contributes to the body of knowledge on group and team creativity. The results tackle the current view on group creativity and how negative effects are dealt with. The comprehensive look on collaboration processes expands the knowledge base by establishing collaboration principles and design guidelines for an effective support of collaborative creativity. This redefines existing theories on collaboration and further expands research on reciprocity, group awareness, TEI and SMM. Additional implications for research provide the results of the conducted experiments for media theories (e.g. MRT, MST and MNT), visualization, collaboration with AI and anchored discussion. Major implications for practice are the designed and implemented artifacts. Companies and organizations can benefit from the way the active IT support was implemented and specific algorithms and functions are used. The results from the experiments indicate that, in order to come up with beneficial ideas, the organization and management of ideas is not enough to relieve the full potential of idea generation. Software that explicitly facilitates creativity is needed to reach and support the full potential of creative individuals and groups. Furthermore, practice can benefit from the results by designing and implementing collaboration software that fosters creativity and draws upon the principles of collaboration. Current approaches that limit collaboration to communication and information sharing, can benefit from the proposed guidelines and the conducted experiments. Practice can therefore highly benefit from the way the artifacts were implemented, displaying the potential of IT, informing about specific algorithms and services that can be used to independently design and implement CSS. In summary, the author's research led to a variety of lessons learned, due to implemented artifacts, systematic literature reviews, conducted experiments and proposed design guidelines, that can help practice to overall improve creativity support and enhance idea- and innovation management. Research results contributed to the body of knowledge on both, IT-supported creativity and collaborative creativity. However, the conducted research understands itself as a first step to shed light on the aspects of IT-supported collaborative creativity. Even though this thesis provides valuable insights and implications for research and practice, the results come with a variety of limitations. The design and implementations of the artifacts are grounded in a not insignificant part on the creativity and capabilities of the author. Selected functions and algorithms do not reflect the current state-of-the-art, but show prototypical possibilities for the use of active IT. These artifacts therefore only represent possible implementations whose functions represent a selected range of possibilities. Furthermore, the conducted experiments and their results mainly depict potential tendencies and possibilities. Due to the small sample sizes of the experiments, no generally valid statements can be made and only possible directions can be pointed out. Within the laboratory and field experiments, possible confounder and external factors could not be completely excluded and a not representative selection of test persons (i.e. mostly students) contribute to a possible falsification of the results. A further limitation is the respective knowledge base, which could not be considered in its entirety, especially due to its range of different research fields (e.g. psychology, philosophy, social science and others). Despite the systematic literature review, specific studies may have been overlooked that could contain possible contributions to the research carried out. The same applies to the considered CSS, which were identified and analyzed. Individual implementations, which are insufficiently documented or published, could contain possible implications for the subject of this dissertation, but could have been overlooked as well. Nonetheless, the conducted research led to a variety of implications, that are valuable for research and practice. When considered and applied in a reflective manner, the results provide a significant value for practice in the design and implementation of CSS and contribute to the research on creativity. However, many aspects like the interplay of IT and creativity, as well as collaborative creativity need to be further investigated in order to fully understand the comprehensive phenomena of creativity.

11.3 Outlook and Final Remarks

Creativity is a complex and extensive phenomenon that involves and requires long and ongoing research (Runco, 2004). Creativity, as an individual ability and thus, as an important resource for companies and organizations is attributed with an immense importance. The support of creativity is therefore an indispensable and essential task in today's society for start-ups to become marketable or for established companies and organizations to ensure a long-term marketability. Special potentials unfold in collaborative creativity, in which synergetic effects are created and used to be creative (Bornemann, 2012; Paulus et al., 2012). Collaboration, and in particular collaborative creativity, involves a number of influencing factors that affect the success of creativity. The principles of collaboration and the design guidelines set out in paper 5 help to design systems that can be specifically developed and implemented for collaborative scenarios to foster creativity. The conducted experiments and the developed artifacts, addressing SMM, Anchored Discussion (AD) and TEI show initial ways to promote collaborative creativity. Nevertheless, further studies need to be carried out and new artifacts need to be developed, involving mechanisms such as reciprocity, benevolence, commitment, team awareness and cohesiveness in collaborative creativity. Evaluations of such mechanisms and functions would contribute to the understanding of collaborative creativity and confirm or disprove the framework and its design guidelines. In addition, aspects such as motivation and self-efficacy play a decisive role in the willingness to participate in collaborative processes (Robra-Bissantz et al., 2017) and have to be further examined within collaborative creativity. Anonymity, a phenomenon that repeatedly leads to different research results (Valacich et al., 1992b; Chen et al., 2014; Connolly et al., 1990), needs to be investigated further, especially in creative collaboration.

Another decisive aspect that must be pursued further is the operationalization of the principles of collaboration and the generically positioned design principles. Each collaboration principle can be implemented in different ways in specific systems. The design guidelines strongly depend on the task to be solved and the context in which the creative process is located (Siemon and Robra-Bissantz, 2016; McCoy and Evans, 2002; Amabile and Gryskiewicz, 1989). New technological advances, innovative functions and new artifacts must be created in order to implement and test the design principles in different ways. The context in which an individual or a group finds itself must also be further investigated, as it has a decisive influence on creativity (Siemon and Robra-Bissantz, 2016) and on aspects of collaboration, such as the TEI (Barczak et al., 2010; Meyer et al., 2017).

A notable technological advance can currently be observed in the field of AI. Paper 1 has already shown that the role of IT is evolving from a passive, organizing and supporting role to an active partnership role. Paper 13 and 7 show first possible design principles and an implemented artifact that changes collaboration with IT in the future. Seeber et al. (2018) argue that the way IS supports collaboration will change in the next years due to human-machine collaboration. In their paper, they propose a research agenda for a new era of collaboration research and mention

AI as one technology that will impact collaboration (Seeber et al., 2018). With this recent evolution, the question arises, how collaboration changes when AI is involved in teamwork.

In summary, collaborative creativity is a far-reaching and complex area. Above all, the many cognitive and social effects involved in collaboration need to be further considered and evaluated by experimental research. Also, the role of IT and the use of active IT elements up to a human-machine collaboration, is one aspect that needs additional investigation. The synthesis of the two addressed objectives (active IT support and collaborative creativity) also requires further research, especially due to the continuous technological development, in which IT plays an important role as a partner in a human-machine collaborative creativity.

Within this thesis the author's research endeavour on IT-supported collaborative creativity is presented. The motivation for the conducted research is the identified lack of active IT within creativity support and the disregard of collaboration principles within group and team creativity. With overall 25 publications, the author contributed various innovative artifacts, exploratory studies and experiment results to the body of knowledge. Nonetheless, further research is needed to shed light on the topic of IT-supported collaborative creativity, to provide valuable insights for companies, organizations, groups, teams and individuals in order get the most out of creativity.

Bibliography

Abowd, Gregory D. and Elizabeth D. Mynatt (2000). “Charting Past, Present, and Future Research in Ubiquitous Computing”. In: *ACM Transactions on Computer-Human Interaction* 7.1, pp. 29–58.

Adamson, Robert E. (1952). “Functional fixedness as related to problem solving: a repetition of three experiments”. In: *Journal of Experimental Psychology* 44.4, pp. 288–291.

Aihara, Kenro and Koichi Hori (1998). “Enhancing creativity through reorganising mental space concealed in a research notes stack”. In: *Knowledge-Based Systems* 11.7-8, pp. 469–478.

Alrushiedat, Nimer and Lorne Olfman (2012). “Anchored Asynchronous Online Discussions: Facilitating Participation and Engagement in a Blended Environment”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 11–20.

Althuizen, Niek and Astrid Reichel (2016). “The Effects of IT-Enabled Cognitive Stimulation Tools on Creative Problem Solving: A Dual Pathway to Creativity”. In: *Journal of Management Information Systems* 33.1, pp. 11–44.

Alvarez, Juan Camilo and Hai-Jun Su (2012). “VRMDS: an intuitive virtual environment for supporting the conceptual design of mechanisms”. In: *Virtual reality* 16.1, pp. 57–68.

Amabile, Teresa M. (1982). “Social psychology of creativity: A consensual assessment technique”. In: *Journal of Personality and Social Psychology* 43.5, pp. 997–1013.

— (1983). “The social psychology of creativity: A componential conceptualization”. In: *Journal of Personality and Social Psychology* 45.2, pp. 357–376.

— (1988). “A model of creativity and innovation in organizations”. In: *Research in organizational behavior* 10.1, pp. 123–167.

— (1996). *Creativity in context: Update to "The Social Psychology of Creativity."* Vol. xviii. Boulder, CO, USA: Westview Press. 317 pp.

Amabile, Teresa M., Regina Conti, Heather Coon, Jeffrey Lazenby, and Michael Herron (1996). "Assessing the Work Environment for Creativity". In: *Academy of Management Journal* 39.5, pp. 1154–1184.

Amabile, Teresa M. and Nur D. Gryskiewicz (1989). "The creative environment scales: Work environment inventory". In: *Creativity Research Journal* 2.4, pp. 231–253.

Amabile, Teresa M. and Michael G. Pratt (2016). "The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning". In: *Research in Organizational Behavior* 36, pp. 157–183.

Ames, Michael and Mark A. Runco (2005). "Predicting Entrepreneurship From Ideation and Divergent Thinking". In: *Creativity and Innovation Management* 14.3, pp. 311–315.

Ardaiz, Oscar, Maria L. S. de Acedo, and Maria T. S. de Acedo (2008). "Wikideas and creativity connector: Supporting group ideational creativity". In: *Proceedings of the 4th International Symposium on Wikis*. ACM, p. 31.

Al-Atabi, Mushtak and Jennifer DeBoer (2014). "Teaching entrepreneurship using massive open online course (MOOC)". In: *Technovation* 34.4, pp. 261–264.

Axelrod, Robert M. and William D. Hamilton (1981). "The evolution of cooperation". In: *Science* 211.4489, pp. 1390–1396.

Azevedo, Diogo, Benjamim Fonseca, Hugo Paredes, Stephan Lukosch, Jordan Janeiro, and Robert O. Briggs (2013). "On the development and usability of a diagram-based collaborative brainstorming component". In: *Journal of Universal Computer Science, 19 (7), 2013*.

Banks, Adrian P. and Lynne J. Millward (2000). "Running shared mental models as a distributed cognitive process". In: *British Journal of Psychology* 91.4, pp. 513–531.

Barczak, Gloria, Felicia Lassk, and Jay Mulki (2010). "Antecedents of Team Creativity: An Examination of Team Emotional Intelligence, Team Trust and Collaborative Culture". In: *Creativity and Innovation Management* 19.4, pp. 332–345.

Barki, Henri and Alain Pinsonneault (2001). "Small Group Brainstorming and Idea Quality Is Electronic Brainstorming the Most Effective Approach?" In: *Small Group Research* 32.2, pp. 158–205.

Baron, Robert and Scott Shane (2007). *Entrepreneurship: A Process Perspective*. Cengage Learning. 497 pp.

Bartelt, Valerie L. and Alan R. Dennis (2014). "Nature and nurture: The impact of automaticity and the structuration of communication on virtual team behavior and performance." In: *MIS Quarterly* 38.2.

Basadur, Min, Mark A. Runco, and Luis A. Vegaxy (2000). "Understanding how creative thinking skills, attitudes and behaviors work together: A causal process model". In: *The Journal of Creative Behavior* 34.2, pp. 77–100.

Baskerville, Richard, Abayomi Baiyere, Shirley Gregor, Alan R. Hevner, and Matti Rossi (2018). "Design Science Research Contributions: Finding a Balance between Artifact and Theory". In: *Journal of the Association for Information Systems* 19.5.

Baskerville, Richard and Michael D. Myers (2004). "Special issue on action research in information systems: Making IS research relevant to practice: Foreword". In: *MIS Quarterly*, pp. 329–335.

Bawden, David (1986). "Information systems and the stimulation of creativity". In: *Journal of Information Science* 12.5, pp. 203–216.

Benedek, Mathias, Caterina Mühlmann, Emanuel Jauk, and Aljoscha C. Neubauer (2013). "Assessment of Divergent Thinking by means of the Subjective Top-Scoring Method: Effects of the Number of Top-Ideas and Time-on-Task on Reliability and Validity". In: *Psychology of aesthetics, creativity, and the arts* 7.4, pp. 341–349.

Bennett, Sue (2004). "Supporting collaborative project teams using computer-based technologies". In: *Online collaborative learning: Theory and practice*, pp. 1–27.

Berge, Zane L. and Mauri P. Collins (1995). *Computer mediated communication and the online classroom: distance learning*. Hampton press Cresskill.

Bertoni, Marco and Koteshwar Chirumalla (2011). "Leveraging Web 2.0 in new product development: Lessons learned from a cross-company study." In: *Journal of Universisal Computer Science* 17.4, pp. 548–564.

Besold, Tarek R., Marco Schorlemmer, and Alan Smaill (2015). *Computational creativity research: towards creative machines*. 1st ed. Vol. 7. Atlantis Thinking Machines. Atlantis Press.

Bhagwatwar, Akshay, Anne Massey, and Alan R. Dennis (2013). "Creative virtual environments: Effect of supraliminal priming on team brainstorming". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 215–224.

Bijlsma, Katinka and Paul Koopman (2003). "Introduction: trust within organisations". In: *Personnel Review* 32.5, pp. 543–555.

Bischof, Nicole and Martin J. Eppler (2011). "Caring for Clarity in Knowledge Communication." In: *Journal of Universal Computer Science* 17.10, pp. 1455–1473.

Bittner, Eva A. C. and Jan M. Leimeister (2014). "Creating shared understanding in heterogeneous work groups: Why it matters and how to achieve it". In: *Journal of Management Information Systems* 31.1, pp. 111–144.

Blaser, Andreas D., Monika Sester, and Max J. Egenhofer (2000). "Visualization in an early stage of the problem-solving process in GIS". In: *Computers & Geosciences* 26.1, pp. 57–66.

Blau, Peter (1977). *Inequality and Heterogeneity: A Primitive Theory of Social Structure*. New York: Macmillan Co. 307 pp.

Bligh, Donald A. (1998). *What's the Use of Lectures?* Intellect Books. 324 pp.

Blohm, Ivo, Ulrich Bretschneider, Jan M. Leimeister, and Helmut Krcmar (2010). "Does Collaboration among Participants Lead to Better Ideas in IT-Based Idea Competitions? An Empirical Investigation". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

Bodemer, Daniel and Jessica Dehler (2011). "Group awareness in CSCL environments". In: *Computers in Human Behavior*. Group Awareness in CSCL Environments 27.3, pp. 1043–1045.

Boden, Margaret A. (1996). *Dimensions of Creativity*. London, UK: MIT Press. 260 pp.

— (1998). "Creativity and artificial intelligence". In: *Artificial Intelligence* 103.1, pp. 347–356.

— (2009). "Computer Models of Creativity". In: *AI Magazine* 30.3, p. 23.

De Bono, Edward (2015). *Serious Creativity: How to be creative under pressure and turn ideas into action*. Random House.

— (1994). "Creativity and quality." In: *Quality Management in Healthcare* 2.3, pp. 1–4.

Booth, Andrew, Anthea Sutton, and Diana Papaioannou (2016). *Systematic approaches to a successful literature review*. Sage.

Bornemann, Stefan (2012). *Kooperation und Kollaboration: Das Kreative Feld als Weg zu innovativer Teamarbeit*. VS Verlag für Sozialwissenschaften.

Bossche, Piet, Wim Gijselaers, Mien Segers, Geert Woltjer, and Paul Kirschner (2010). "Team learning: building shared mental models". In: *Instructional Science* 39.3, pp. 283–301.

Bowers, Clint A., James A. Pharmer, and Eduardo Salas (2000). "When Member Homogeneity is Needed in Work Teams: A Meta-Analysis". In: *Small Group Research* 31.3, pp. 305–327.

Brade, Marius, Joerg Heseler, and Rainer Groh (2011). "BrainDump: an interface for visual information-gathering during web browsing sessions". In: *Proceedings of the 11th International Conference on Knowledge Management and Knowledge Technologies*, p. 25.

Bradley, John H. and Frederic J. Hebert (1997). "The effect of personality type on team performance". In: *Journal of Management Development* 16.5, pp. 337–353.

Brewer, Marilynn B. (1979). "In-group bias in the minimal intergroup situation: A cognitive-motivational analysis". In: *Psychological Bulletin* 86.2, pp. 307–324.

Briggs, Robert O. (2006). "On theory-driven design and deployment of collaboration systems". In: *International Journal of Human-Computer Studies*. Theoretical and empirical advances in groupware research 64.7, pp. 573–582.

Briggs, Robert O., Gert-Jan de Vreede, and Jay F. Nunamaker (2003). "Collaboration engineering with ThinkLets to pursue sustained success with group support systems". In: *Journal of Management Information Systems* 19.4, pp. 31–64.

Briggs, Robert O. and Bruce A. Reinig (2007). "Bounded Ideation Theory: A New Model of the Relationship Between Ideaquantity and Idea-quality during Ideation". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, p. 16.

Briggs, Robert O., Bruce A. Reinig, and Gert-Jan de Vreede (2006). "Meeting satisfaction for technology-supported groups: An empirical validation of a goal-attainment model". In: *Small Group Research* 37.6, pp. 585–611.

Briggs, Robert O., Bruce Reinig, and Gert-Jan de Vreede (2008). "The Yield Shift Theory of Satisfaction and Its Application to the IS/IT Domain". In: *Journal of the Association for Information Systems* 9.5.

Broder, Andrei Z. (2000). "Identifying and filtering near-duplicate documents". In: *Annual Symposium on Combinatorial Pattern Matching*. Springer, pp. 1–10.

Brophy, Dennis R. (2001). “Comparing the Attributes, Activities, and Performance of Divergent, Convergent, and Combination Thinkers”. In: *Creativity Research Journal* 13.3, pp. 439–455.

Brown, Susan A, Alan R Dennis, and Viswanath Venkatesh (2010). “Predicting collaboration technology use: Integrating technology adoption and collaboration research”. In: *Journal of Management Information Systems* 27.2, pp. 9–54.

Bruffee, Kenneth A. (1999). *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. ERIC.

Bryan-Kinns, Nick (2013). “Mutual engagement and collocation with shared representations”. In: *International Journal of Human-Computer Studies* 71.1, pp. 76–90.

Buchanan, Richard (1992). “Wicked Problems in Design Thinking”. In: *Design Issues* 8.2, pp. 5–21.

Bullinger, Angelika (2008). *Innovation and Ontologies: Structuring the Early Stages of Innovation Management*. Wiesbaden: Springer Science & Business Media. 430 pp.

Bunderson, J. Stuart and Kathleen M. Sutcliffe (2002). “Comparing Alternative Conceptualizations of Functional Diversity in Management Teams: Process and Performance Effects”. In: *The Academy of Management Journal* 45.5, pp. 875–893.

Bunnin, Nicholas and Jiyuan Yu (2007). *The Blackwell Dictionary of Western Philosophy*. Blackwell Publishing Inc.

Burkus, David (2013). *The Myths of Creativity: The Truth About How Innovative Companies and People Generate Great Ideas*. 1st ed. San Francisco: John Wiley & Sons. 224 pp.

Busch, Michael W. and Dietrich von der Oelsnitz (2016). “Emergente Teamphänomene–Warum sich Erfolge eines Teams nicht einfach kopieren lassen”. In: *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO)* 47.4, pp. 345–355.

Cannon-Bowers, Janis A. and Eduardo Salas (2001). “Reflections on shared cognition”. In: *Journal of Organizational Behavior* 22.2, pp. 195–202.

Cannon-Bowers, Janis A., Eduardo Salas, and Sharolyn Converse (1993). “Shared mental models in expert team decision making”. In: *Individual and group decision making: Current issues* 221, pp. 221–246.

Card, Stuart K. (1989). “Theory-Driven Design Research”. In: *Applications of Human Performance Models to System Design*. Springer, Boston, MA, pp. 501–509.

Carell, Angela and Thomas Herrmann (2010). "Interaction and collaboration modes for integrating inspiring information into technology-enhanced creativity workshops". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

Cavallucci, Denis, François Rousselot, and Cécilia Zanni (2011). "An ontology for TRIZ". In: *Procedia Engineering* 9, pp. 251–260.

Chae, Seong W., Young W. Seo, and Kun C. Lee (2015). "Task difficulty and team diversity on team creativity: Multi-agent simulation approach". In: *Computers in Human Behavior*. Digital Creativity: New Frontier for Research and Practice 42, pp. 83–92.

Chamorro-Premuzic, Tomas and Lisa Reichenbacher (2008). "Effects of personality and threat of evaluation on divergent and convergent thinking". In: *Journal of Research in Personality* 42.4, pp. 1095–1101.

Chen, Fang, Limin Zhang, and Joseph Latimer (2014). "How much has my co-worker contributed? The impact of anonymity and feedback on social loafing in asynchronous virtual collaboration". In: *International Journal of Information Management* 34.5, pp. 652–659.

Cheng, Jing-de (2001). "Autonomous evolutionary information systems". In: *Wuhan University Journal of Natural Sciences* 6, pp. 333–339.

Cheng, Xusen, Shixuan Fu, and Douglas Druckenmiller (2016). "Trust development in globally distributed collaboration: A case of US and Chinese mixed teams". In: *Journal of Management Information Systems* 33.4, pp. 978–1007.

Chermahini, Soghra Akbari and Bernhard Hommel (2012). "Creative mood swings: divergent and convergent thinking affect mood in opposite ways". In: *Psychological research* 76.5, pp. 634–640.

Cherry, Erin and Celine Latulipe (2014). "Quantifying the Creativity Support of Digital Tools Through the Creativity Support Index". In: *ACM Trans. Comput.-Hum. Interact.* 21.4, 21:1–21:25.

Chesbrough, Henry W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

— (2013). *Open Business Models: How To Thrive In The New Innovation Landscape*. Harvard Business Press. 252 pp.

Chesbrough, Henry W., Wim Vanhaverbeke, and Joel West (2006). *Open Innovation: Researching a New Paradigm*. OUP Oxford. 400 pp.

Chester, Andrea and Gillian Gwynne (1998). "Online Teaching: Encouraging Collaboration through Anonymity". In: *Journal of Computer-Mediated Communication* 4.2.

Chiu, Ivey and Li H. Shu (2012). "Investigating effects of oppositely related semantic stimuli on design concept creativity". In: *Journal of Engineering Design* 23.4, pp. 271–296.

Cohen, Susan G. and Diane E. Bailey (1997). "What Makes Teams Work: Group Effectiveness Research from the Shop Floor to the Executive Suite". In: *Journal of Management* 23.3, pp. 239–290.

Cole, Robert, Sandeep Purao, Matti Rossi, and Maung Sein (2005). "Being Proactive: Where Action Research Meets Design Research". In: *International Conference on Information Systems (ICIS)*.

Colton, Simon and Geraint A. Wiggins (2012). "Computational Creativity: The Final Frontier?" In: *Proceedings of the 20th European Conference on Artificial Intelligence*. Amsterdam, The Netherlands: IOS Press, pp. 21–26.

Connolly, Terry, Leonard M. Jessup, and Joseph S. Valacich (1990). "Effects of Anonymity and Evaluative Tone on Idea Generation in Computer-mediated Groups". In: *Manage. Sci.* 36.6, pp. 689–703.

Connolly, Terry, Robert L. Routhieaux, and Sherry K. Schneider (1993). "On the Effectiveness of Group Brainstorming Test of One Underlying Cognitive Mechanism". In: *Small Group Research* 24.4, pp. 490–503.

Cooke, Nancy J., Eduardo Salas, Janis A. Cannon-Bowers, and Renee J. Stout (2000). "Measuring team knowledge". In: *Human Factors* 42.1, pp. 151–173.

Cooper, Robert G. (1990). "Stage-gate systems: a new tool for managing new products". In: *Business horizons* 33.3, pp. 44–54.

Corvera Charaf, Marianne, Christoph Rosenkranz, and Roland Holten (2013). "The emergence of shared understanding: applying functional pragmatics to study the requirements development process". In: *Information Systems Journal* 23.2, pp. 115–135.

Costa, Ana C. (2003). "Work team trust and effectiveness". In: *Personnel Review* 32.5, pp. 605–622.

Couger, J. Daniel, Lexis F. Higgins, and Scott C. McIntyre (1993). "(Un) structured creativity in information systems organizations". In: *MIS Quarterly*, pp. 375–397.

Cronbach, Lee J. (1951). "Coefficient alpha and the internal structure of tests". In: *Psychometrika* 16.3, pp. 297–334.

Cropley, David H. (2016). "Measuring Capacity for Innovation in Local Government Organizations". In: *Journal of Creativity and Business Innovation* 1, pp. 31–45.

Csikszentmihalyi, Mihaly (1997). *Creativity: Flow and the Psychology of Discovery and Invention*. New York: Harper Perennial. 464 pp.

— (2013). *Creativity: The Psychology of Discovery and Invention*. Harper Perennial. 480 pp.

Curtis, Aaron M., Alan R. Dennis, and Kelly O. McNamara (2017). "From Monologue to Dialogue: Using Performative Objects to Promote Collective Mindfulness in Computer-Mediated Team Discussions". In: *MIS Quarterly* 41.2.

Daft, Richard L. and Robert H. Lengel (1986). "Organizational information requirements, media richness and structural design". In: *Management science* 32.5, pp. 554–571.

Danneels, Erwin (2002). "The dynamics of product innovation and firm competences". In: *Strategic Management Journal* 23.12, pp. 1095–1121.

Davis, Nicholas, Alexander Zook, Brian O'Neill, Brandon Headrick, Mark Riedl, Ashton Grosz, and Michael Nitsche (2013). "Creativity support for novice digital filmmaking". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 651–660.

Dean, Douglas L., Jillian M. Hender, Thomas L. Rodgers, and Eric L. Santanen (2006). "Identifying Quality, Novel, and Creative Ideas: Constructs and Scales for Idea Evaluation". In: *Journal of the Association for Information Systems* 7.1, p. 30.

Dehn, Doris M. and Susanne Van Mulken (2000). "The impact of animated interface agents: a review of empirical research". In: *International Journal of Human-Computer Studies* 52.1, pp. 1–22.

Dennen, Vanessa P. (2000). "Task structuring for on-line problem based learning: A case study". In: *Educational Technology & Society* 3.3, pp. 329–336.

Dennis, Alan R., Jay E. Aronson, William G. Heninger, and Edward D. Walker II (1999). "Structuring Time and Task in Electronic Brainstorming". In: *MIS Quarterly* 23.1, pp. 95–108.

Dennis, Alan R., Robert M. Fuller, and Joseph S. Valacich (2008). “Media, Tasks, and Communication Processes: A Theory of Media Synchronicity”. In: *MIS Quarterly* 32.3, pp. 575–600.

Dennis, Alan R. and Joseph S. Valacich (1993). “Computer brainstorms: More heads are better than one.” In: *Journal of Applied Psychology* 78.4, pp. 531–537.

— (1999). “Rethinking Media Richness: Towards a Theory of Media Synchronicity”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA: IEEE Computer Society, pp. 1017–.

Dennis, Alan R., Joseph S. Valacich, Traci A. Carte, Monica J. Garfield, Barbara J. Haley, and Jay E. Aronson (1997). “Research Report: The Effectiveness of Multiple Dialogues in Electronic Brainstorming”. In: *Information Systems Research* 8.2, pp. 203–211.

Dennis, Alan R., Joseph S. Valacich, Terry Connolly, and Bayard E. Wynne (1996). “Process Structuring in Electronic Brainstorming”. In: *Information Systems Research* 7.2, pp. 268–277.

Dennis, Alan R. and Mike L. Williams (2003). “Electronic brainstorming: Theory, research, and future directions”. In: *Group creativity: Innovation through collaboration*. Ed. by Paul B. Paulus and Bernard A. Nijstad. New York, NY, US: Oxford University Press, pp. 160–178.

DeTienne, Dawn R. and Gaylen N. Chandler (2004). “Opportunity Identification and Its Role in the Entrepreneurial Classroom: A Pedagogical Approach and Empirical Test”. In: *Academy of Management Learning & Education* 3.3, pp. 242–257.

Diehl, Michael and Wolfgang Stroebe (1987). “Productivity loss in brainstorming groups: Toward the solution of a riddle”. In: *Journal of Personality and Social Psychology* 53.3, pp. 497–509.

— (1991). “Productivity loss in idea-generating groups: Tracking down the blocking effect”. In: *Journal of Personality and Social Psychology* 61.3, pp. 392–403.

Van Dijk, Jelle and Gerrit W. Vos (2011). “Traces in creative spaces”. In: *Proceedings of the 8th ACM conference on Creativity and cognition*. ACM, pp. 91–94.

Dillenbourg, Pierre, Michael J. Baker, Agnes Blaye, and Claire O’Malley (1995). *The evolution of research on collaborative learning*. Elsevier, Oxford.

Disselkamp, Marcus (2012). *Innovationsmanagement: Instrumente und Methoden zur Umsetzung im Unternehmen*. 2nd ed. Gabler Verlag.

Druskat, Vanessa Urch and Steven B. Wolff (2001). "Group emotional intelligence and its influence on group effectiveness". In: *The emotionally intelligent workplace: How to select for, measure, and improve emotional intelligence in individuals, groups and organizations*, pp. 132–155.

Dugosh, Karen L. and Paul B. Paulus (2005). "Cognitive and social comparison processes in brainstorming". In: *Journal of Experimental Social Psychology* 41.3, pp. 313–320.

Duncan, Nancy and David B. Paradice (1992). "Creativity in GDSS: an integration of creativity, group dynamics, and problem solving theory". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 277–287.

Duncker, Karl (1945). "On problem-solving." Trans. by Lynne S. Lees. In: *Psychological Monographs* 58.5, pp. i–113.

Earley, Christopher P. and Elaine Mosakowski (2000). "Creating Hybrid Team Cultures: An Empirical Test of Transnational Team Functioning". In: *The Academy of Management Journal* 43.1, pp. 26–49.

Evans, Charles R. and Kenneth L. Dion (2012). "Group Cohesion and Performance: A Meta-Analysis". In: *Small Group Research* 43.6, pp. 690–701.

Farooq, Umer, John M. Carroll, and Craig H. Canoe (2008). "Designing for creativity in computer-supported cooperative work". In: *International Journal of e-Collaboration* 4.4, pp. 51–75.

Farooq, Umer, John M. Carroll, and Craig H. Ganoe (2005). "Supporting creativity in distributed scientific communities". In: *Proceedings of the 2005 international ACM SIGGROUP conference on Supporting group work*. ACM, pp. 217–226.

Fellbaum, Christiane (2012). "WordNet". In: *The Encyclopedia of Applied Linguistics*. Blackwell Publishing Ltd.

Fern, Edward F. (1982). "The Use of Focus Groups for Idea Generation: The Effects of Group Size, Acquaintanceship, and Moderator on Response Quantity and Quality". In: *Journal of Marketing Research* 19.1, pp. 1–13.

Fillis, Ian (2007). "A methodology for researching international entrepreneurship in SMEs: A challenge to the status quo". In: *Journal of Small Business and Enterprise Development* 14.1, pp. 118–135.

Fillis, Ian and Ruth Rentschler (2005). "Using creativity to achieve an entrepreneurial future for arts marketing". In: *International Journal of Nonprofit and Voluntary Sector Marketing* 10.4, pp. 275–287.

— (2010). "The Role of Creativity in Entrepreneurship". In: *Journal of Enterprising Culture* 18.1, pp. 49–81.

Fink, Andreas, Roland H. Grabner, Daniela Gebauer, Gernot Reishofer, Karl Koschutnig, and Franz Ebner (2010). "Enhancing creativity by means of cognitive stimulation: Evidence from an fMRI study". In: *NeuroImage* 52.4, pp. 1687–1695.

Finke, Ronald A., Thomas B. Ward, and Steven M. Smith (1996). *Creative Cognition: Theory, Research, and Applications*. Cambridge, Mass.: A Bradford Book. 256 pp.

Fischer, Frank, Johannes Bruhn, Cornelia Gräsel, and Heinz Mandl (2002). "Fostering collaborative knowledge construction with visualization tools". In: *Learning and Instruction* 12.2, pp. 213–232.

Fischer, Gerhard, Elisa Giaccardi, Hal Eden, Masanori Sugimoto, and Yunwen Ye (2005). In: *International Journal of Human-Computer Studies* 63.4, pp. 482–512.

Fjermestad, Jerry and Starr Roxanne Hiltz (1998). "An Assessment of Group Support Systems Experimental Research: Methodology and Results". In: *Journal of Management Information Systems* 15.3, pp. 7–149.

Flynn, Michael, Lawrence Dooley, D O'sullivan, and K Cormican (2003). "Idea management for organisational innovation". In: *International Journal of innovation management* 7.04, pp. 417–442.

Ford, Nigel (1999). "Information retrieval and creativity: towards support for the original thinker". In: *Journal of Documentation* 55.5, pp. 528–542.

Forés, Beatriz and César Camisón (2016). "Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size?" In: *Journal of Business Research* 69.2, pp. 831–848.

Forster, Florian (2009). "Improving creative thinking abilities using a generic collaborative creativity support system". In: *Research, reflections and innovations in integrating ICT in education*, pp. 539–543.

Forster, Florian and Michele Brocco (2008). "Understanding Creativity-Technique Based Problem Solving Processes". In: *Knowledge-Based Intelligent Information and Engineering*

Systems. Ed. by Ignac Lovrek, Robert J. Howlett, and Lakhmi C. Jain. Lecture Notes in Computer Science 5178. Springer Berlin Heidelberg, pp. 806–813.

Forsyth, Donelson R. (2014). *Group dynamics*. 6th ed. Belmont, CA: Wadsworth Cengage Learning.

Franco, Massimo and Nicola D'Angelo (2011). *Creativity in Work Team: A Case Study*. SSRN Scholarly Paper. Rochester, NY: Social Science Research Network.

Funke, Joachim (2009). "Complex problem solving: a case for complex cognition?" In: *Cognitive Processing* 11.2, pp. 133–142.

Gabriel, Alex, Davy Monticolo, Mauricio Camargo, and Mario Bourgault (2016). "Creativity support systems: A systematic mapping study". In: *Thinking Skills and Creativity* 21, pp. 109–122.

Gallupe, R. Brent, Alan R. Dennis, William H. Cooper, Joseph S. Valacich, Lana M. Bastianutti, and Jay F. Nunamaker (1992). "Electronic Brainstorming And Group Size". In: *Academy of Management Journal* 35.2, pp. 350–369.

García-Álvarez, María T., Laura Varela-Candamio, and Isabel Novo-Corti (2014). "Chat as a Tool for Social Knowledge Construction Using Asynchronous Discussion Groups in Economics Degree." In: *Journal of Universal Computer Science* 20.10, pp. 1443–1458.

Gassmann, Oliver and Marco Zeschky (2008). "Opening up the Solution Space: The Role of Analogical Thinking for Breakthrough Product Innovation". In: *Creativity and Innovation Management* 17.2, pp. 97–106.

Germonprez, Matt and Matt Levy (2015). "Is it Egalitarianism or Enterprise Strategy? Exploring a New Method of Innovation in Open Source". In: Americas Conference on Information Systems (AMCIS). Puerto Rico, USA.

Gerosa, Marco A., Mariano Pimentel, Hugo Fuks, and Carlos J. P. de Lucena (2006). "Development of Groupware Based on the 3C Collaboration Model and Component Technology". In: *Groupware: Design, Implementation, and Use*. Ed. by Yannis A. Dimitriadis, Ilze Zigurs, and Eduardo Gómez-Sánchez. Lecture Notes in Computer Science 4154. Springer Berlin Heidelberg, pp. 302–309.

Geyer, Florian, Daniel Klinkhammer, and Harald Reiterer (2010). "Supporting creativity workshops with interactive tabletops and digital pen and paper". In: *ACM International Conference on Interactive Tabletops and Surfaces*. ACM, pp. 261–262.

Gibbons, Jean Dickinson and Subhabrata Chakraborti (2011). "Nonparametric Statistical Inference". In: *International Encyclopedia of Statistical Science*. Ed. by Miodrag Lovric. Springer Berlin Heidelberg, pp. 977–979.

Gibson, Cristina B. and Jennifer L. Gibbs (2006). "Unpacking the Concept of Virtuality: The Effects of Geographic Dispersion, Electronic Dependence, Dynamic Structure, and National Diversity on Team Innovation". In: *Administrative Science Quarterly* 51.3, pp. 451–495.

Gick, Mary L. and Keith J. Holyoak (1980). "Analogical problem solving". In: *Cognitive Psychology* 12.3, pp. 306–355.

Gielnik, Michael M. (2013). "Kreativität und Entrepreneurship". In: *Kreativität, Innovation, Entrepreneurship*. Ed. by Diana E. Krause. Springer Fachmedien Wiesbaden, pp. 77–92.

Gielnik, Michael M., Michael Frese, Johanna M. Graf, and Anna Kampschulte (2012). "Creativity in the opportunity identification process and the moderating effect of diversity of information". In: *Journal of Business Venturing* 27.5, pp. 559–576.

Golbeck, Jennifer (2009). "Trust and Nuanced Profile Similarity in Online Social Networks". In: *ACM Transactions on the Web* 3.4, 12:1–12:33.

Goldschmidt, Gabriela (2007). "To see eye to eye: the role of visual representations in building shared mental models in design teams". In: *CoDesign* 3.1, pp. 43–50.

Gregor, Shirley and Alan R. Hevner (2013). "Positioning and Presenting Design Science Research for Maximum Impact". In: *MIS Quarterly* 37.2, pp. 337–356.

Griffin, Garth and Robert Jacob (2013). "Priming creativity through improvisation on an adaptive musical instrument". In: *Proceedings of the 9th ACM Conference on Creativity & Cognition*. ACM, pp. 146–155.

Gross, Tom, Chris Stary, and Alex Totter (2005). "User-Centered Awareness in Computer-Supported Cooperative Work-Systems: Structured Embedding of Findings from Social Sciences". In: *International Journal of Human–Computer Interaction* 18.3, pp. 323–360.

Guilford, Joy P. (1950). "Creativity". In: *American Psychologist* 5.9, pp. 444–454.

Gulati, Ranjay, Franz Wohlgezogen, and Pavel Zhelyazkov (2012). "The Two Facets of Collaboration: Cooperation and Coordination in Strategic Alliances". In: *The Academy of Management Annals* 6.1, pp. 531–583.

Gutwein, Sonja (2013). "Computer support for collaborative creativity". In: *Beyond the Desktop*, p. 15.

Hackman, J. Richard (1987). “The design of work teams”. In: *Handbook of organizational behavior*. Ed. by J. Lorsch. Englewood Cliffs, NJ: Prentice-Hall.

Hackman, J. Richard and Charles G. Morris (1975). “Group Tasks, Group Interaction Process, and Group Performance Effectiveness: A Review and Proposed Integration”. In: *Advances in Experimental Social Psychology* 8 (C), pp. 45–99.

Hailpern, Joshua, Erik Hinterbichler, Caryn Leppert, Damon Cook, and Brian P Bailey (2007). “TEAM STORM: demonstrating an interaction model for working with multiple ideas during creative group work”. In: *Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition*. ACM, pp. 193–202.

Harrison, David A., Kenneth H. Price, and Myrtle P. Bell (1998). “Beyond Relational Demography: Time and the Effects of Surface- and Deep-Level Diversity on Work Group Cohesion”. In: *The Academy of Management Journal* 41.1, pp. 96–107.

Harrison, David A., Kenneth H. Price, Joanne H. Gavin, and Anna T. Florey (2002). “Time, Teams, and Task Performance: Changing Effects of Surface- and Deep-Level Diversity on Group Functioning”. In: *The Academy of Management Journal* 45.5, pp. 1029–1045.

Hartmann, Björn, Meredith Ringel Morris, Hrvoje Benko, and Andrew D. Wilson (2010). “Pictionaire: Supporting Collaborative Design Work by Integrating Physical and Digital Artifacts”. In: *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work*. CSCW ’10. New York, NY, USA: ACM, pp. 421–424.

Hauschildt, Jürgen, Sören Salomo, Carsten Schultz, and Alexander Kock (2016). *Innovationsmanagement (6. Auflage)*. Vahlens Handbücher der Wirtschafts- und Sozialwissenschaften. Vahlen.

Hayen, Roger L., Stephanie A. Swaby, and Zhenyu Huang (2007). “Use of group support systems in today’s society”. In: *Issues in Information Systems* 8.2, pp. 120–126.

Heinrich, Lutz J., Armin Heinzl, and René Riedl (2011). *Wirtschaftsinformatik: Einführung und Grundlegung*. 4th ed. Springer-Lehrbuch. Berlin Heidelberg: Springer-Verlag.

Helpman, Elhanan (2010). *The Mystery of Economic Growth*. London, England: Harvard University Press. 240 pp.

Hender, Jillian M., Douglas L. Dean, Thomas L. Rodgers, and Jay F. Nunamaker (2002). “An Examination of the Impact of Stimuli Type and GSS Structure on Creativity: Brainstorming versus Non-Brainstorming Techniques in a GSS Environment”. In: *Journal of Management Information Systems* 18.4, pp. 59–85.

Hennessey, Beth A. and Teresa M. Amabile (2010). “Creativity”. In: *Annual Review of Psychology* 61.1, pp. 569–598.

Herring, Scarlett R., Brett R. Jones, and Brian P. Bailey (2009). “Idea Generation Techniques among Creative Professionals”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

Hesmer, Alexander, Karl A. Hribernik, Jannicke M. Baalsrud Hauge, and Klaus-Dieter Thoben (2011). “Supporting the ideation processes by a collaborative online based toolset”. In: *International journal of technology management* 55.3/4, pp. 218–225.

Hevner, Alan R., Salvatore T. March, Jinsoo Park, and Sudha Ram (2004). “Design Science in Information Systems Research”. In: *MIS Quarterly* 28.1, pp. 75–105.

Hilliges, Otmar, Lucia Terrenghi, Sebastian Boring, David Kim, Hendrik Richter, and Andreas Butz (2007). “Designing for Collaborative Creative Problem Solving”. In: *Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition*. New York, NY, USA: ACM, pp. 137–146.

Hiltz, Starr R. (1998). “Collaborative Learning in Asynchronous Learning Networks: Building Learning Communities.” In: WEB98 conference. Orlando, Florida, USA.

Hocevar, Dennis (1980). “Intelligence, divergent thinking, and creativity”. In: *Intelligence* 4.1, pp. 25–40.

Hoever, Inga J., Daan van Knippenberg, Wendy P. van Ginkel, and Harry G. Barkema (2012). “Fostering team creativity: perspective taking as key to unlocking diversity’s potential”. In: *The Journal of Applied Psychology* 97.5, pp. 982–996.

Hollan, James, Edwin Hutchins, and David Kirsh (2000). “Distributed cognition: toward a new foundation for human-computer interaction research”. In: *ACM Transactions on Computer-Human Interaction (TOCHI)* 7.2, pp. 174–196.

Hord, Shirley M. (1981). “Working Together: Cooperation or Collaboration?” In: *Communications Services, Research and Development Center for Teacher Education,* 3.203.

Howard, Thomas J., Stephen J. Culley, and Elies Dekoninck (2008). “Describing the creative design process by the integration of engineering design and cognitive psychology literature”. In: *Design studies* 29.2, pp. 160–180.

Howard, Thomas J., Elies A. Dekoninck, and Steve J. Culley (2010). "The use of creative stimuli at early stages of industrial product innovation". In: *Research in Engineering Design* 21.4, pp. 263–274.

Hrastinski, Stefan, Niklas Z Kviselius, Håkan Ozan, and Mats Edenius (2010). "A Review of Technologies for Open Innovation: Characteristics and Future Trends". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

Huang, Chun-Chieh, Li Tsai-Yen, Wang Hao-Chuan, and Chun-Yen Chang (2007). "Idea storming cube: A game-based system to support creative thinking". In: International Workshop on Digital Games and Intelligent Toys-based Education (DIGITEL). IEEE, pp. 179–181.

Humphreys, Patrick and Garrick Jones (2006). "The Evolution Of Group Decision Support Systems To Enable Collaborative Authoring Of Outcomes". In: *World Futures* 62.3, pp. 193–222.

Huttner, Jan-Paul and Susanne Robra-Bissantz (2016). "A Design Science Approach to High Immersive Mnemonic E-learning". In: Mediterranean Conference on Information Systems (MCIS).

Indurkhya, Bipin, Kailash Kattalay, Amitash Ojha, and Pradhee Tandon (2008). "Experiments with a Creativity-Support System based on Perceptual Similarity." In: *SoMeT*, pp. 316–327.

Ivcevic, Zorana and John D. Mayer (2006). "Creative types and personality". In: *Imagination, cognition and personality* 26.1, pp. 65–86.

Jackson, Jeffrey M. and Kipling D. Williams (1985). "Social loafing on difficult tasks: Working collectively can improve performance." In: *Journal of personality and social psychology* 49.4, p. 937.

Järvinen, Pertti (2007). "Action Research is Similar to Design Science". In: *Quality & Quantity* 41.1, pp. 37–54.

Jauk, Emanuel, Mathias Benedek, Beate Dunst, and Aljoscha C Neubauer (2013). "The relationship between intelligence and creativity: New support for the threshold hypothesis by means of empirical breakpoint detection". In: *Intelligence* 41.4, pp. 212–221.

Javadi, Elahe, Judith Gebauer, and Joseph Mahoney (2013). "The Impact of User Interface Design on Idea Integration in Electronic Brainstorming: An Attention-Based View". In: *Journal of the Association for Information Systems* 14.1.

Jehn, Karen A., Gregory B. Northcraft, and Margaret A. Neale (1999). "Why differences make a difference: A field study of diversity, conflict and performance in workgroups". In: *Administrative science quarterly* 44.4, pp. 741–763.

Jeong, Heisawn and Michelene T. H. Chi (2007). "Knowledge convergence and collaborative learning". In: *Instructional Science* 35.4, pp. 287–315.

Jessup, Leonard M., Terry Connolly, and Jolene Galegher (1990). "The Effects of Anonymity on GDSS Group Process with an Idea-Generating Task". In: *MIS Quarterly* 14.3, pp. 313–321.

Johnson, David W. and Roger T. Johnson (1985). "Relationships between black and white students in intergroup cooperation and competition". In: *The Journal of Social Psychology* 125.4, pp. 421–428.

— (1989). *Cooperation and competition: Theory and research.* Interaction Book Company.

Johnson, David W., Roger T. Johnson, and Karl A. Smith (1998). *Active learning: Cooperation in the college classroom.* ERIC.

Johnson, Tristan E., Youngmin Lee, Miyoung Lee, Debra L. O'Connor, Mohammed K. Khalil, and Xiaoxia Huang (2007). "Measuring Sharedness of Team-Related Knowledge: Design and Validation of a Shared Mental Model Instrument". In: *Human Resource Development International* 10.4, pp. 437–454.

Jones, Alistair, Atman Kendira, Dominique Lenne, Thierry Gidel, and Claude Moulin (2011). "The TATIN-PIC project: A multi-modal collaborative work environment for preliminary design". In: *Computer Supported Cooperative Work in Design (CSCWD), 2011 15th International Conference on*. IEEE, pp. 154–161.

Ju, Wendy, Lawrence Neeley, Terry Winograd, and Larry Leifer (2006). "Thinking with erasable ink: Ad-hoc whiteboard use in collaborative design". In: *CDR Technical Report* 20060928, p. 52.

Kadefors, Anna (2004). "Trust in project relationships-inside the black box". In: *International Journal of project management* 22.3, pp. 175–182.

Kallookaran, Michael and Susanne Robra-Bissantz (2016). "Using Gamification to Decrease Anonymity in Larger Learning Environments". In: Americas Conference on Information Systems (AMCIS). San Diego, USA.

— (2017). "Reaching beyond the Classroom through the Use of Push Notifications". In: Americas Conference on Information Systems (AMCIS).

Kanawattanachai, Prasert and Youngjin Yoo (2007). "The Impact of Knowledge Coordination on Virtual Team Performance over Time". In: *MIS Quarterly* 31.4, pp. 783–808.

Kaplan, Andreas M and Michael Haenlein (2010). "Users of the world, unite! The challenges and opportunities of Social Media". In: *Business horizons* 53.1, pp. 59–68.

Karau, Steven J. and Kipling D. Williams (1993). "Social loafing: A meta-analytic review and theoretical integration". In: *Journal of Personality and Social Psychology* 65.4, pp. 681–706.

— (1997). "The effects of group cohesiveness on social loafing and social compensation". In: *Group Dynamics: Theory, Research, and Practice* 1.2, pp. 156–168.

— (2001). "Understanding individual motivation in groups: The collective effort model". In: *Groups at work: Theory and research*, pp. 113–141.

Kasper-Fuehrera, Eva C. and Neal M. Ashkanasy (2001). "Communicating trustworthiness and building trust in interorganizational virtual organizations". In: *Journal of Management* 27.3, pp. 235–254.

Kermanidis, Katia, Manolis Maragoudakis, Spyros Vosinakis, and Nikos Exadaktylos (2013). "Designing a Support Tool for Creative Advertising by Mining Collaboratively Tagged Ad Video Content: The Architecture of PromONTotion". In: *IFIP International Conference on Artificial Intelligence Applications and Innovations*. Springer, pp. 10–19.

Kerne, Andruid, Eunyee Koh, Steven M. Smith, Andrew Webb, and Blake Dworaczyk (2008). "combinFormation: Mixed-initiative composition of image and text surrogates promotes information discovery". In: *ACM Transactions on Information Systems (TOIS)* 27.1, p. 5.

Kerr, Norbert L. (1983). "Motivation losses in small groups: A social dilemma analysis". In: *Journal of Personality and Social Psychology* 45.4, pp. 819–828.

Kerr, Norbert L. and Steven E. Bruun (1982). "Dispensability of member effort and group motivation losses: Free-rider effects." In: *Journal of Personality and Social Psychology* 44.1, pp. 78–94.

Kim, Jieun, Carole Bouchard, Jean-François Omhover, and Améziane Aoussat (2012). "Designing a graphical interface for creativity support tools for designers: a case study". In: *International Journal of Web Engineering and Technology* 7.2.

Kirchgeorg, Volker, Markus Achtert, and Hanno Großechmidth (2010). *Pathways to Innovation Excellence – Results of a Global Study*. Technology and Innovation Management.

Kirkman, Bradley L. and John E. Mathieu (2005). "The Dimensions and Antecedents of Team Virtuality". In: *Journal of Management* 31.5, pp. 700–718.

Kirschner, Femke, Fred Paas, and Paul A. Kirschner (2009). "A Cognitive Load Approach to Collaborative Learning: United Brains for Complex Tasks". In: *Educational Psychology Review* 21.1, pp. 31–42.

Klimoski, Richard J. and Susan Mohammed (1994). "Team Mental Model: Construct or Metaphor?" In: *Journal of Management* 20.2, pp. 403–437.

Van Knippenberg, Daan, Carsten K. W. De Dreu, and Astrid C. Homan (2004). "Work group diversity and group performance: an integrative model and research agenda". In: *The Journal of Applied Psychology* 89.6, pp. 1008–1022.

Knoll, Stefan W. and Graham Horton (2010). "Changing the Perspective: Improving Generate thinkLets for Ideation". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

— (2011). "The Impact of Stimuli Characteristics on the Ideation Process: An Evaluation of the Change of Perspective 'Analogy'". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 1–10.

Knoll, Stefan W., Graham Horton, Claudia Krull, and Tim Dittmar (2015). "Improving the Effectiveness of Ideation Using Analogies: Choosing the Right External Stimuli". In: *Journal of Creativity and Business Innovation* 1, pp. 5–18.

Ko, Stephen and John E. Butler (2007). "Creativity: A key link to entrepreneurial behavior". In: *Business Horizons* 50.5, pp. 365–372.

Kock, Ned (2004). "The psychobiological model: Towards a new theory of computer-mediated communication based on Darwinian evolution". In: *Organization science* 15.3, pp. 327–348.

Koh, Eunyee, Andruid Kerne, and Rodney Hill (2007). "Creativity support: information discovery and exploratory search". In: *Proceedings of the 30th annual international ACM SIGIR conference on Research and development in information retrieval*. ACM, pp. 895–896.

Kosorukoff, Alex (2001). "Human based genetic algorithm". In: IEEE International Conference on Systems, Man, and Cybernetics. Vol. 5, pp. 3464–3469.

Kozbelt, Aaron, Ronald A. Beghetto, and Mark A. Runco (2010). "Theories of creativity". In: *The Cambridge handbook of creativity* 2, pp. 20–47.

Kozlowski, Steve and Bradford Bell (2008). "Team Learning, Development, and Adaptation". In: *Articles and Chapters*.

Kraemer, Kenneth L. and John L. King (1988). "Computer-based Systems for Cooperative Work and Group Decision Making". In: *ACM Computing Surveys* 20.2, pp. 115–146.

Krampen, Günter (1997). "Promotion of creativity (divergent productions) and convergent productions by systematic-relaxation exercises: empirical evidence from five experimental studies with children, young adults, and elderly". In: *European Journal of Personality* 11.2, pp. 83–99.

Kreijns, Karel, Paul A. Kirschner, and Wim Jochems (2003). "Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research". In: *Computers in Human Behavior* 19.3, pp. 335–353.

Kules, Bill (2005). *Supporting creativity with search tools*. Report from a U.S. National Science Foundation Sponsored Workshop, pp. 53–64.

Kung, Howard and Lukas Schmid (2015). "Innovation, Growth, and Asset Prices". In: *The Journal of Finance* 70.3, pp. 1001–1037.

Kunifuji, Susumu and Naotaka Kato (2007). "Consensus-making support systems dedicated to creative problem solving". In: *International Journal of Information Technology & Decision Making* 6.03, pp. 459–474.

Laal, Marjan and Seyed Mohammad Ghodsi (2012). "Benefits of collaborative learning". In: *Procedia-Social and Behavioral Sciences* 31, pp. 486–490.

Lamprecht, Jens, Dominik Siemon, and Susanne Robra-Bissantz (2016). "Cooperation Isn't Just About Doing the Same Thing – Using Personality for a Cooperation-Recommender-System in Online Social Networks". In: International Conference on Collaboration and Technology. Springer, Cham, pp. 131–138.

Langan-Fox, Janice, Jeromy Anglim, and John R. Wilson (2004). "Mental models, team mental models, and performance: Process, development, and future directions". In: *Human Factors and Ergonomics in Manufacturing & Service Industries* 14.4, pp. 331–352.

Lattemann, Christoph and Susanne Robra-Bissantz (2005). "Customer integration–social and technology based concepts for a customer governance". In: *Frontiers of e-Business Research*, pp. 193–205.

Lawler, Edward J., Shane R. Thye, and Jeongkoo Yoon (2000). "Emotion and Group Cohesion in Productive Exchange". In: *American Journal of Sociology* 106.3, pp. 616–657.

Leana, Carrie R. and Harry J. van Buren (1999). "Organizational Social Capital and Employment Practices". In: *The Academy of Management Review* 24.3, pp. 538–555.

Leavy, Brian (2012). "Collaborative innovation as the new imperative–design thinking, value co-creation and the power of "pull"". In: *Strategy & Leadership* 40.2, pp. 25–34.

Lee, Sang M., David L. Olson, and Silvana Trimi (2012). "Co-innovation: convergenomics, collaboration, and co-creation for organizational values". In: *Management Decision* 50.5, pp. 817–831.

Lewin, Kurt (1946). "Action research and minority problems". In: *Journal of social issues* 2.4, pp. 34–46.

Liikkanen, Lassi A., Kai Kuikkaniemi, Petri Lievonen, and Pauli Ojala (2011). "Next step in electronic brainstorming: collaborative creativity with the web". In: Conference on Human Factors in Computing Systems. ACM, pp. 2029–2034.

Likert, Rensis (1932). "A technique for the measurement of attitudes". In: *Archives of Psychology* 22 140, p. 55.

Lim, Beng-Chong and Katherine J. Klein (2006). "Team mental models and team performance: a field study of the effects of team mental model similarity and accuracy". In: *Journal of Organizational Behavior* 27.4, pp. 403–418.

Link, Georg J. P., Dominik Siemon, Gert-Jan de Vreede, and Susanne Robra-Bissantz (2015). "Evaluating Anchored Discussion to Foster Creativity in Online Collaboration". In: *Collaboration and Technology*. Ed. by Nelson Baloian, Yervant Zorian, Perouz Taslakian, and Samvel Shoukouryan. Lecture Notes in Computer Science 9334. Springer International Publishing, pp. 28–44.

— (2016). "Anchored Discussion: Development of a Tool for Creativity in Online Collaboration". In: *Journal of Universal Computer Science* 22.10, pp. 1339–1359.

Lipnack, Jessica and Jeffrey Stamps (1997). *Virtual Teams: Reaching Across Space, Time, and Organizations with Technology*. Jeffrey Stamps. 296 pp.

Liu, XiaoYing, Yan Li, PeiYuan Pan, and WenQiang Li (2011). "Research on computer-aided creative design platform based on creativity model". In: *Expert systems with applications* 38.8, pp. 9973–9990.

Liu, Zhicheng, Nancy Nersessian, and John Stasko (2008). "Distributed cognition as a theoretical framework for information visualization". In: *IEEE transactions on visualization and computer graphics* 14.6.

Lopes, J. Sousa, Sergio Álvarez-Napagao, and Javier Vazquez-Salceda (2009). "USE: a concept-based recommendation system to support creative search". In: *International Joint Conferences on Web Intelligence and Intelligent Agent Technologies*. Vol. 3. IEEE, pp. 17–21.

Lubart, Todd (2005). "How Can Computers Be Partners in the Creative Process: Classification and Commentary on the Special Issue". In: *International Journal of Human-Computer Studies* 63.4, pp. 365–369.

Lugger, Kurt-Martin and Herbert Kraus (2001). "Mastering the human barriers in knowledge management". In: *Journal of Universal Computer Science* 7.6, pp. 488–497.

Lurey, Jeremy S. and Mahesh S. Raisinghani (2001). "An Emprical Study of Best Practices in Virtual Teams". In: *Information & Management* 38.8, pp. 523–544.

MacCrimmon, Kenneth R. and Christian Wagner (1994). "Stimulating Ideas Through Creativity Software". In: *Management Science* 40.11, pp. 1514–1532.

Malaga, Ross A. (2000). "The effect of stimulus modes and associative distance in individual creativity support systems". In: *Decision Support Systems* 29.2, pp. 125–141.

Mamykina, Lena, Linda Candy, and Ernest Edmonds (2002). "Collaborative Creativity". In: *Commun. ACM* 45.10, pp. 96–99.

Mangano, Nicolas, Alex Baker, Mitch Dempsey, Emily Navarro, and André van der Hoek (2010). "Software design sketching with calico". In: *Proceedings of the IEEE/ACM international conference on Automated software engineering*. ACM, pp. 23–32.

Markus, M. Lynne, Ann Majchrzak, and Les Gasser (2002). "A design theory for systems that support emergent knowledge processes". In: *MIS Quarterly*, pp. 179–212.

Martins, Luis L., Lucy L. Gilson, and M. Travis Maynard (2004). "Virtual Teams: What Do We Know and Where Do We Go From Here?" In: *Journal of Management* 30.6, pp. 805–835.

Massetti, Brenda (1996). "An Empirical Examination of the Value of Creativity Support Systems on Idea Generation". In: *MIS Quarterly* 20.1, pp. 83–97.

Massetti, Brenda, Norman H. White, and Valerie K. Spitler (1999). "The impact of the World Wide Web on idea generation". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, p. 5.

Mathieu, John E., Tonia S. Heffner, Gerald F. Goodwin, Eduardo Salas, and Janis A. Cannon-Bowers (2000). "The influence of shared mental models on team process and performance". In: *Journal of Applied Psychology* 85.2, pp. 273–283.

Mattessich, Paul W. and Barbara R. Monsey (1992). *Collaboration: What Makes It Work. A Review of Research Literature on Factors Influencing Successful Collaboration.* Amherst H. Wilder Foundation, St. Paul, MN, USA.

Mayer, Richard E. (1999). "22 Fifty Years of Creativity Research". In: *Handbook of creativity* 449.

Maynard, M. Travis and Lucy L. Gilson (2014). "The role of shared mental model development in understanding virtual team effectiveness". In: *Group & Organization Management* 39.1, pp. 3–32.

McComb, Mary (1994). "Benefits of computer-mediated communication in college courses". In: *Communication Education* 43.2, pp. 159–170.

McCoy, Janetta Mitchell and Gary W. Evans (2002). "The Potential Role of the Physical Environment in Fostering Creativity". In: *Creativity Research Journal* 14.3, pp. 409–426.

McGrath, Rita G. (2001). "Exploratory Learning, Innovative Capacity and Managerial Oversight". In: *The Academy of Management Journal* 44.1, pp. 118–131.

McInnerney, Joanne M. and Tim S. Roberts (2004). "Collaborative or cooperative learning". In: *Online collaborative learning: Theory and practice*, pp. 203–214.

McMullen, Jeffery S. and Dean A. Shepherd (2006). "Entrepreneurial Action And The Role Of Uncertainty In The Theory Of The Entrepreneur". In: *Academy of Management Review* 31.1, pp. 132–152.

Mednick, Sarnoff (1962). "The associative basis of the creative process". In: *Psychological Review* 69.3, pp. 220–232.

Meyer, Michael, Patrick Helmholz, and Susanne Robra-Bissantz (2017). "Digital Transformation in Retail: Can Customer Value Services enhance the Experience?" In: Proceedings of the Bled eConference. Bled, Slovenia.

Milliken, Frances J. and Luis L. Martins (1996). "Searching for common threads: Understanding the multiple effects of diversity in organizational groups". In: *Academy of management review* 21.2, pp. 402–433.

Miyazoe, Terumi and Terry Anderson (2011). "Anonymity in Blended Learning: Who Would You like to Be?" In: *Educational Technology & Society* 14.2, pp. 175–187.

Mohammed, Susan, Richard J. Klimoski, and Joan R. Rentsch (2000). "The Measurement of Team Mental Models: We Have No Shared Schema". In: *Organizational Research Methods* 3.2, pp. 123–165.

Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G. Altman (2010). "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement". In: *International Journal of Surgery* 8.5, pp. 336–341.

Morschheuser, Benedikt, Juho Hamari, Karl Werder, and Julian Abe (2017). "How to gamify? A method for designing gamification". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA.

Mullen, Brian, Craig Johnson, and Eduardo Salas (1991). "Productivity Loss in Brainstorming Groups: A Meta-Analytic Integration". In: *Basic and Applied Social Psychology* 12.1, pp. 3–23.

Müller-Wienbergen, Felix, Oliver Müller, Stefan Seidel, and Jörg Becker (2011). "Leaving the Beaten Tracks in Creative Work – A Design Theory for Systems that Support Convergent and Divergent Thinking". In: *Journal of the Association for Information Systems* 12.11.

Mumford, Michael D., Kelsey E. Medeiros, and Paul J. Partlow (2012). "Creative Thinking: Processes, Strategies, and Knowledge". In: *The Journal of Creative Behavior* 46.1, pp. 30–47.

Mynatt, Elizabeth D., Takeo Igarashi, W. Keith Edwards, and Anthony LaMarca (1999). "Flatland: New Dimensions in Office Whiteboards". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '99. New York, NY, USA: ACM, pp. 346–353.

Nakakoji, Kumiyo (2005). "Seven issues for creativity support tool researchers". In: *Creativity Support Tools*.

Nakazono, Nagayoshi, Kazuo Misue, and Jiro Tanaka (2006). "IdeaCrepe: creativity support tool with history layers". In: *International Conference on Knowledge-Based and Intelligent Information and Engineering Systems*. Springer, pp. 843–850.

Neck, Heidi M., Patricia G. Greene, and Candida G. Brush (2014). *Teaching entrepreneurship: A practice-based approach*. Cheltenham, UK: Edward Elgar Publishing.

Nelson, Kay M. and Jay G. Cooprider (1996). "The Contribution of Shared Knowledge to IS Group Performance". In: *MIS Quarterly* 20.4, pp. 409–432.

Newell, Sue, Carole Tansley, and Jimmy Huang (2004). "Social Capital and Knowledge Integration in an ERP Project Team: The Importance of Bridging AND Bonding". In: *British Journal of Management* 15 (S1), pp. 43–57.

Nijstad, Bernard A. and Wolfgang Stroebe (2006). "How the Group Affects the Mind: A Cognitive Model of Idea Generation in Groups". In: *Personality and Social Psychology Review* 10.3, pp. 186–213.

Nunamaker, Jay F., Lynda M. Applegate, and Benn R. Konsynski (1987). "Facilitating Group Creativity: Experience with a Group Decision Support System". In: *Journal of Management Information Systems* 3.4, pp. 5–19.

Nunamaker, Jay F., Robert O. Briggs, Daniel D. Mittleman, Douglas R. Vogel, and Pierre A. Balthazard (1996). "Lessons from a Dozen Years of Group Support Systems Research: A Discussion of Lab and Field Findings". In: *Journal of Management Information Systems* 13.3, pp. 163–207.

Nunamaker, Jay F., Alan R. Dennis, Joseph S. Valacich, Douglas Vogel, and Joey F. George (1991). "Electronic meeting systems". In: *Communications of the ACM* 34.7, pp. 40–61.

Oehlberg, Lora, Jasmine Jones, Alice Agogino, and Björn Hartmann (2012). "Dazzle: supporting framing in co-located design teams through remote collaboration tool". In: *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work Companion*. ACM, pp. 183–186.

Olguín, Carlos José M., Armando Luiz N. Delgado, and Ivan Luiz M. Ricarte (2000). "An agent infrastructure to set collaborative environments". In: *Educational Technology & Society* 3.3, pp. 65–73.

Olszak, Celina M. and Jerzy A. Kisielnicki (2016). "Organizational Creativity and IT-based Support". In: *Informing Science: the International Journal of an Emerging Transdiscipline* 19.

Orlikowski, Wanda J. and C. Suzanne Iacono (2001). "Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artifact". In: *Information Systems Research* 12.2, pp. 121–134.

Osborn, Alex F. (1953). *Applied Imagination: Principles and Procedures of Creative Problem Solving*. New York, NY, USA: Charles Scribner's Sons. 317 pp.

Van Osch, Wietske and Michel Avital (2009). "Collective Generativity: The Emergence of IT-Induced Mass Innovation". In: *All Sprouts Content*.

Panitz, Theodore (1999). "Benefits of cooperative learning in relation to student motivation". In: *Motivationfrom within: Approaches for encouraging faculty and students to excel, New directions for teaching and learning. San Francisco, CA*.

Panitz, Theodore and Patricia Panitz (1999). *Assessing Students and Yourself Using the One Minute Paper and Observing Students Working Cooperatively*. ERIC.

Parkhurst, Howard B. (1999). "Confusion, Lack of Consensus, and the Definition of Creativity as a Construct". In: *The Journal of Creative Behavior* 33.1, pp. 1–21.

Paulhus, Delroy L. and Simine Vazire (2007). "The self-report method". In: *Handbook of research methods in personality psychology*. Ed. by Richard W. Robins, R. Chris Fraley, and Robert F. Krueger. New York, NY, USA: Guilford Press, pp. 224–239.

Paulus, Paul B. (1989). *Psychology of Group Influence*. Psychology Press. 462 pp.

— (2000). "Groups, Teams, and Creativity: The Creative Potential of Idea-generating Groups". In: *Applied Psychology* 49.2, pp. 237–262.

Paulus, Paul B., Mary Dzindolet, and Nicholas W. Kohn (2012). "Collaborative Creativity - Group Creativity and Team Innovation". In: *Handbook of Organizational Creativity*. San Diego: Academic Press, pp. 327–357.

Paulus, Paul B. and Bernard A. Nijstad (2009). *Group Creativity: Innovation Through Collaboration*. New York: Oxford Univ Pr. 368 pp.

Peffers, Ken, Tuure Tuunanen, Marcus Rothenberger, and Samir Chatterjee (2007). "A Design Science Research Methodology for Information Systems Research". In: *Journal of Management Information Systems* 24.3, pp. 45–77.

Pelled, Lisa H., Kathleen M. Eisenhardt, and Katherine R. Xin (1999). "Exploring the Black Box: An Analysis of Work Group Diversity, Conflict, and Performance". In: *Administrative Science Quarterly* 44.1, pp. 1–28.

Pirola-Merlo, Andrew and Leon Mann (2004). “The relationship between individual creativity and team creativity: aggregating across people and time”. In: *Journal of Organizational Behavior* 25.2, pp. 235–257.

Van der Pol, Jakko, Wilfried Admiraal, and P. Robert-Jan Simons (2006). “The affordance of anchored discussion for the collaborative processing of academic texts”. In: *International Journal of Computer-Supported Collaborative Learning* 1.3, pp. 339–357.

Pomerol, Jean-Charles (1997). “Artificial intelligence and human decision making”. In: *European Journal of Operational Research* 99.1, pp. 3–25.

Porter, Martin F. (1980). “An algorithm for suffix stripping”. In: *Program: electronic library and information systems* 14.3, pp. 130–137.

Power, Daniel J. and Ramesh Sharda (2009). “Decision Support Systems”. In: *Springer Handbook of Automation*. Springer, Berlin, Heidelberg, pp. 1539–1548.

Proctor, Robert A. (1993). “A Creative Decision Support System”. In: *Leadership & Organization Development Journal* 14.2, pp. 13–17.

Pundt, Alexander and Birgit Schyns (2005). “Führung im Ideenmanagement: Der Zusammenhang zwischen transformationaler Führung und dem individuellen Engagement im Ideenmanagement”. In: *Zeitschrift für Personalpsychologie* 4.2, pp. 55–65.

Raghuram, Sumita, Philipp Tuertscher, and Raghu Garud (2010). “Research note - Mapping the field of virtual work: A cocitation analysis”. In: *Information Systems Research* 21.4, pp. 983–999.

Randrup, Nils, Douglas Druckenmiller, and Robert O. Briggs (2016). “Philosophy of Collaboration”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA.

Ray, Michael and Rochelle Myers (1988). *Creativity in Business*. Reissue. New York: Main Street Books. 240 pp.

Redlich, Beke, Dominik Siemon, Christoph Lattemann, and Susanne Robra-Bissantz (2017). “Shared Mental Models in Creative Virtual Teamwork”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA.

Reinig, Bruce A. and Robert O. Briggs (2006). “Measuring the Quality of Ideation Technology and Techniques”. In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 20–20.

— (2008). "On The Relationship Between Idea-Quantity and Idea-Quality During Ideation". In: *Group Decision and Negotiation* 17.5, pp. 403–420.

Reinig, Bruce, Robert O. Briggs, and Jay F. Nunamaker (2007). "On the Measurement of Ideation Quality". In: *Journal of Management Information Systems* 23.4, pp. 143–161.

Rentsch, Joan R. and Richard J. Klimoski (2001). "Why do 'great minds' think alike?: antecedents of team member schema agreement". In: *Journal of Organizational Behavior* 22.2, pp. 107–120.

Resick, Christian J., Toshio Murase, Wendy L. Bedwell, Elizabeth Sanz, Miliani Jiménez, and Leslie A. DeChurch (2010). "Mental model metrics and team adaptability: A multi-facet multi-method examination". In: *Group Dynamics: Theory, Research, and Practice* 14.4, pp. 332–349.

Resnick, Mitchel, Brad Myers, Kumiyo Nakakoji, Ben Shneiderman, Randy Pausch, Ted Selker, and Mike Eisenberg (2005). "Design Principles for Tools to Support Creative Thinking". In: *NSF Workshop Report on Creativity Support Tools*. Citeseer, pp. 25–36.

Rhodes, Mel (1961). "An Analysis of Creativity". In: *The Phi Delta Kappan* 42.7, pp. 305–310.

Riconscente, Michelle M. (2013). "Results From a Controlled Study of the iPad Fractions Game Motion Math". In: *Games and Culture* 8.4, pp. 186–214.

Riordan, Christine M. and Lynn McFarlane Shore (1997). "Demographic diversity and employee attitudes: An empirical examination of relational demography within work units." In: *Journal of applied psychology* 82.3, p. 342.

Roberts, Tim S. and Joanne M. McInnerney (2007). "Seven problems of online group learning (and their solutions)". In: *Educational Technology & Society* 10.4, pp. 257–268.

Robra-Bissantz, Susanne (2018). "Entwicklung von innovativen Services in der Digitalen Transformation". In: *Service Business Development*. Springer, pp. 261–288.

Robra-Bissantz, Susanne, Felix Becker, Pascal Abel, and Cedric Handke (2017). "Das „e-" in Partizipation". In: *HMD Praxis der Wirtschaftsinformatik* 54.4, pp. 461–476.

De Rooij, Alwin, Philip J. Corr, and Sara Jones (2015). "Emotion and creativity: Hacking into cognitive appraisal processes to augment creative ideation". In: *Proceedings of the Conference on Creativity and Cognition*. ACM, pp. 265–274.

Roschelle, Jeremy and Stephanie D. Teasley (1995). "The construction of shared knowledge in collaborative problem solving". In: *Computer supported collaborative learning*. Springer, pp. 69–97.

Van Rosmalen, Peter, Jo Boon, Marlies Bitter-Rijpkema, Rory Sie, and Peter Sloep (2014). "Supporting co-creation with software, the idSpace platform". In: *Computers in Human Behavior* 37, pp. 413–422.

Rouse, William B., Janis A. Cannon-Bowers, and Eduardo Salas (1992). "The role of mental models in team performance in complex systems". In: *IEEE Transactions on Systems, Man, and Cybernetics* 22.6, pp. 1296–1308.

Rouse, William B. and Nancy M. Morris (1986). "On looking into the black box: Prospects and limits in the search for mental models". In: *Psychological Bulletin* 100.3, pp. 349–363.

Runco, Mark A. (2004). "Creativity". In: *Annual Review of Psychology* 55.1, pp. 657–687.

Runco, Mark A. and Selcuk Acar (2012). "Divergent Thinking as an Indicator of Creative Potential". In: *Creativity Research Journal* 24.1, pp. 66–75.

Ryan, Janette and Rosemary Viete (2009). "Respectful interactions: Learning with international students in the English-speaking academy". In: *Teaching in Higher education* 14.3, pp. 303–314.

Salas, Eduardo, C. Shawn Burke, and Janis A. Cannon-Bowers (2000). "Teamwork: emerging principles". In: *International Journal of Management Reviews* 2.4, pp. 339–356.

Salton, Gerard and Michael J. McGill (1983). *Introduction to modern information retrieval*. McGraw-Hill. 470 pp.

Salzman, Marilyn C., Chris Dede, R. Bowen Loftin, and Jim Chen (1999). "A model for understanding how virtual reality aids complex conceptual learning". In: *Presence: Teleoperators and Virtual Environments* 8.3, pp. 293–316.

Santanen, Eric L., Robert O. Briggs, and Gert-Jan de Vreede (1999). "A Cognitive Network Model of Creativity: A Renewed Focus on Brainstorming Methodology". In: *International Conference on Information Systems (ICIS)*. Atlanta, USA, pp. 489–494.

— (2000). "The cognitive network model of creativity: a new causal model of creativity and a new brainstorming technique". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, p. 10.

— (2003). "The impact of stimulus diversity on creative solution generation: an evaluation of the cognitive network model of creativity". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, p. 10.

— (2004). "Causal Relationships in Creative Problem Solving: Comparing Facilitation Interventions for Ideation". In: *Journal of Management Information Systems* 20.4, pp. 167–198.

Santos, Catarina M., Sjir Uitdewilligen, and Ana M. Passos (2015). "Why is Your Team More Creative Than Mine? The Influence of Shared Mental Models on Intra-group Conflict, Team Creativity and Effectiveness". In: *Creativity and Innovation Management* 24.4, pp. 645–658.

Satzinger, John W., Monica J. Garfield, and Murli Nagasundaram (1999). "The Creative Process: The Effects of Group Memory on Individual Idea Generation". In: *Journal of Management Information Systems* 15.4, pp. 143–160.

Sawhney, Mohanbir, Gianmario Verona, and Emanuela Prandelli (2005). "Collaborating to create: The Internet as a platform for customer engagement in product innovation". In: *Journal of Interactive Marketing* 19.4, pp. 4–17.

Sawyer, R. Keith and Stacy DeZutter (2009). "Distributed creativity: How collective creations emerge from collaboration". In: *Psychology of Aesthetics, Creativity, and the Arts* 3.2, pp. 81–92.

Schouten, Alexander P., Bart van den Hooff, and Frans Feldberg (2016). "Virtual team work: Group decision making in 3D virtual environments". In: *Communication Research* 43.2, pp. 180–210.

Schrader, Jürgen (1991). "Innovationsförderung als Führungsaufgabe". In: *Aspekte des Innovationsmanagements*. Springer, pp. 15–41.

Schumpeter, Joseph A. (1934). *The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interest, and the Business Cycle*. Transaction Publishers. 324 pp.

Seeber, Isabella, Eva Bittner, Robert O. Briggs, Gert-Jan de Vreede, Triparna de Vreede, Douglas Druckenmiller, Ronald Maier, Alexander B. Merz, Sarah Oeste-Reiß, Nils Randrup, Gerhard Schwabe, and Matthias Söllner (2018). "Machines as Teammates: A Collaboration Research Agenda". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA.

Seidel, Stefan, Felix Müller-Wienbergen, and Jörg Becker (2010). "The Concept of Creativity in the Information Systems Discipline: Past, Present, and Prospects". In: *Communications of the Association for Information Systems* 27.1.

Sein, Maung, Ola Henfridsson, Sandeep Purao, Matti Rossi, and Rikard Lindgren (2011). "Action Design Research". In: *MIS Quarterly*.

Setchi, Rossitza and Carole Bouchard (2010). "In search of design inspiration: a semantic-based approach". In: *Journal of Computing and Information Science in Engineering* 10.3, p. 031006.

Shah, Chirag, Roberto González-Ibáñez, and Pam Read (2015). "Investigating impacts of spatial configurations on collaborative writing". In: *First Monday* 20.12.

Shah, Jami J., Steve M. Smith, and Noe Vargas-Hernandez (2003). "Metrics for measuring ideation effectiveness". In: *Design Studies* 24.2, pp. 111–134.

Shalley, Christina E., Lucy L. Gilson, and Terry C. Blum (2009). "Interactive Effects of Growth Need Strength, Work Context, and Job Complexity on Self-Reported Creative Performance". In: *The Academy of Management Journal* 52.3, pp. 489–505.

Shane, Scott A. (2003). *A General Theory of Entrepreneurship: The Individual-opportunity Nexus*. Edward Elgar Publishing. 356 pp.

Shen, Siu-Tsen, Stephen D. Prior, Anthony S. White, and Mehmet Karamanoglu (2007). "Using personality type differences to form engineering design teams." In: *Engineering Education* 2.2, pp. 54–66.

Shepherd, Morgan M., Robert O. Briggs, Bruce A. Reinig, Jerome Yen, and Jay F. Nunamaker (1995). "Invoking Social Comparison to Improve Electronic Brainstorming: Beyond Anonymity". In: *J. Manage. Inf. Syst.* 12.3, pp. 155–170.

Shibata, Hirohito and Koichi Hori (2003). "An information management system with the facility to support long-term creative thinking". In: *New Generation Computing* 21.1, pp. 23–36.

Shneiderman, Ben (2007). "Creativity Support Tools: Accelerating Discovery and Innovation". In: *Communications of the ACM* 50.12, pp. 20–32.

Siangliulue, Pao, Joel Chan, Bernd Huber, Steven P. Dow, and Krzysztof Z. Gajos (2016). "IdeaHound: Self-sustainable Idea Generation in Creative Online Communities". In: *Proceedings of the Conference on Computer Supported Cooperative Work and Social Computing Companion*. ACM, pp. 98–101.

Siemon, Dominik, Sorour Khalili Narani, Kristin Ostermeier, and Susanne Robra-Bissantz (2016). "Creativity and Entrepreneurship - The Role of Creativity Support Systems for Start-ups". In: Mediterranean Conference on Information Systems (MCIS).

Siemon, Dominik and Susanne Robra-Bissantz (2014). "Integration of Information Retrieval in Creativity Support: A Prototype to Support Divergent Thinking". In: *Advancing the Impact of Design Science: Moving from Theory to Practice*. Ed. by Monica C. Tremblay, Debra VanderMeer, Marcus Rothenberger, Ashish Gupta, and Victoria Yoon. Lecture Notes in Computer Science 8463. Springer International Publishing, pp. 388–392.

— (2016). "Design Guidelines for Context-Aware Creativity Support Systems". In: *Journal of Creativity and Business Innovation* 1, pp. 5–19.

Simons, Tony, Lisa H. Pelled, and Ken A. Smith (1999). "Making Use of Difference: Diversity, Debate, and Decision Comprehensiveness in Top Management Teams". In: *The Academy of Management Journal* 42.6, pp. 662–673.

Singh, Charan (2016). *HCD vs Design Thinking vs Service Design vs UX - What do they all mean?* Medium. URL: https://medium.com/@charan3/hcd-vs-design-thinking-vs-service-design-vs-ux-what-do-they-all-mean-4927fb248fa1 (visited on 07/31/2018).

Slavin, Robert E. (1980). "Cooperative learning". In: *Review of educational research* 50.2, pp. 315–342.

Smith, Gerald F. (1998). "Idea-Generation Techniques: A Formulary of Active Ingredients". In: *The Journal of Creative Behavior* 32.2, pp. 107–134.

Smith, J. Brock and Donald W. Barclay (1997). "The Effects of Organizational Differences and Trust on the Effectiveness of Selling Partner Relationships". In: *Journal of Marketing* 61.1, pp. 3–21.

Somech, Anit and Anat Drach-Zahavy (2013). "Translating Team Creativity to Innovation Implementation The Role of Team Composition and Climate for Innovation". In: *Journal of Management* 39.3, pp. 684–708.

Sonnenburg, Stephan (2007). *Kooperative Kreativität: Theoretische Basisentwürfe und organisationale Erfolgsfaktoren*. Springer-Verlag. 286 pp.

Sorapure, Madeleine (2010). "Information visualization, web 2.0, and the teaching of writing". In: *Computers and Composition* 27.1, pp. 59–70.

Souitaris, Vangelis, Stefania Zerbinati, and Andreas Al-Laham (2007). "Do entrepreneurship programmes raise entrepreneurial intention of science and engineering students? The effect of learning, inspiration and resources". In: *Journal of Business Venturing* 22.4, pp. 566–591.

Stadermann, Melanie (2011). *SchülerInnen und Lehrpersonen in mediengestützten Lernumgebungen: Zwischen Wissensmanagement und sozialen Aushandlungsprozessen*. Verlag für Sozialwissenschaften.

Staples, Sandy, Ian Wong, and Peter B. Seddon (2002). "Having expectations of information systems benefits that match received benefits: does it really matter?" In: *Information & Management* 40.2, pp. 115–131.

Stefik, Mark, Gregg Foster, Daniel G. Bobrow, Kenneth Kahn, Stan Lanning, and Lucy Suchman (1987). "Beyond the chalkboard: computer support for collaboration and problem solving in meetings". In: *Communications of the ACM* 30.1, pp. 32–47.

Steiner, Ivan Dale (1972). *Group Processes and Productivity*. Academic Press. 224 pp.

Stockleben, Björn, Martyn Thayne, Seija Jäminki, Ilkka Haukijärvi, Nicholas Blessing Mavengere, Muhammet Demirbilek, and Mikko Ruohonen (2016). "Towards a framework for creative online collaboration: A research on challenges and context". In: *Education and Information Technologies*, pp. 1–23.

Stroebe, Wolfgang and Michael Diehl (1994). "Why groups are less effective than their members: on productivity losses in idea-generating groups". In: *European review of social psychology* 5.1, pp. 271–303.

Stumpf, Stephen A. and Roger L. M. Dunbar (1991). "The Effects of Personality Type on Choices Made in Strategic Decision Situations". In: *Decision Sciences* 22.5, pp. 1047–1072.

Sugimoto, Masanori, Koichi Hori, and Setsuo Ohsuga (1996). "A system to visualize different viewpoints for supporting researchers' creativity". In: *Knowledge-Based Systems* 9.6, pp. 369–376.

Swaab, Roderick I., Tom Postmes, Peter Neijens, Marius H. Kiers, and Adrie C. M. Dumay (2002). "Multiparty Negotiation Support: The Role of Visualization's Influence on the Development of Shared Mental Models". In: *Journal of Management Information Systems* 19.1, pp. 129–150.

Tajfel, Henri (1974). "Social identity and intergroup behaviour". In: *Information (International Social Science Council)* 13.2, pp. 65–93.

Tang, Anthony, Joel Lanir, Saul Greenberg, and Sidney Fels (2009). "Supporting transitions in work: informing large display application design by understanding whiteboard use". In: *Proceedings of the ACM 2009 international conference on Supporting group work*. ACM, pp. 149–158.

Tasa, Kevin, Simon Taggar, and Gerard H. Seijts (2007). "The development of collective efficacy in teams: a multilevel and longitudinal perspective". In: *The Journal of Applied Psychology* 92.1, pp. 17–27.

Tavakol, Mohsen and Reg Dennick (2011). "Making sense of Cronbach's alpha". In: *International Journal of Medical Education* 2, pp. 53–55.

Taylor, Alva and Henrich R. Greve (2006). "Superman or the Fantastic Four? Knowledge Combination and Experience in Innovative Teams". In: *The Academy of Management Journal* 49.4, pp. 723–740.

Thomas, David R. (2006). "A general inductive approach for analyzing qualitative evaluation data". In: *American journal of evaluation* 27.2, pp. 237–246.

Thomas, Dominic M. and Robert P. Bostrom (2007). "The Role of a Shared Mental Model of Collaboration Technology in Facilitating Knowledge Work in Virtual Teams". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 37–37.

Tidd, Joe (2006). "A review of innovation models". In: *Imperial College London* 16.

Tinto, Vincent (1997). "Enhancing learning via community." In: *Thought & Action* 13.1, pp. 53–58.

Tinzmann, Margaret B., Beau F. Jones, Todd F. Fennimore, Jan Bakker, Carole Fine, and Jean Pierce (1990). "What is the collaborative classroom". In: *Proceedings of NCREL*.

Tiwana, Amrit and Ephraim R. McLean (2005). "Expertise Integration and Creativity in Information Systems Development". In: *Journal of Management Information Systems* 22.1, pp. 13–43.

Tiwana, Amrit and Ephraim R. Mclean (2003). "Expertise Integration and Creativity in Information Systems Development". In: *Journal of Management Information Systems* 22.1, pp. 13–43.

Townsend, Anthony M., Samuel M. DeMarie, and Anthony R. Hendrickson (1998). "Virtual teams: Technology and the workplace of the future". In: *The Academy of Management Executive* 12.3, pp. 17–29.

Tripathi, Neha, Hock S. Seah, Steven John Zuiker, Margaret Tan, Heather Kvill, Tomas Y. K. Ho, Chang K. Xin, Yixiang Lu, and Yuefeng Li (2009). "Visuapedia: A social media based visual encyclopedia". In: *Proceedings of the first SIGMM workshop on Social media*. ACM, pp. 89–96.

Tuckman, Bruce W. (1965). "Developmental sequence in small groups." In: *Psychological bulletin* 63.6, p. 384.

Tuckman, Bruce W. and Mary A. C. Jensen (1977). "Stages of small-group development revisited". In: *Group & Organization Studies* 2.4, pp. 419–427.

Turner, John C., Michael A. Hogg, Penelope J. Oakes, Stephen D. Reicher, and Margaret S. Wetherell (1987). *Rediscovering the social group: A self-categorization theory.* Basil Blackwell.

Urbach, Nils and Frederik Ahlemann (2016). *IT-Management im Zeitalter der Digitalisierung*. Springer.

Vahs, Dietmar and Alexander Brem (2015). *Innovationsmanagement: Von der Idee zur erfolgreichen Vermarktung*. Praxisnahes Wirtschaftsstudium. Schäffer-Poeschel.

Vaishnavi, Vijay K. and William Kuechler (2015). *Design science research methods and patterns: innovating information and communication technology*. Crc Press.

Valacich, Joseph S., Alan R. Dennis, and Terry Connolly (1994). "Idea Generation in Computer-Based Groups: A New Ending to an Old Story". In: *Organizational Behavior and Human Decision Processes* 57.3, pp. 448–467.

Valacich, Joseph S., Alan R. Dennis, and Jay F. Nunamaker (1992a). "Group Size and Anonymity Effects on Computer-Mediated Idea Generation". In: *Small Group Research* 23.1, pp. 49–73.

Valacich, Joseph S., Leonard M. Jessup, Alan R. Dennis, and Jay F. Nunamaker (1992b). "A conceptual framework of anonymity in Group Support Systems". In: *Group Decision and Negotiation* 1.3, pp. 219–241.

Vandenbosch, Betty, Argun Saatcioglu, and Sharon Fay (2006). "Idea management: a systemic view". In: *Journal of Management Studies* 43.2, pp. 259–288.

VanGundy, Arthur B (1992). *Idea power: Techniques & resources to unleash the creativity in your organization*. New York, USA: American Management Association.

VanGundy, Arthur B. (2008). *101 Activities for Teaching Creativity and Problem Solving*. San Francisco, USA: John Wiley & Sons. 411 pp.

Vattam, Swaroop, Bryan Wiltgen, Michael Helms, Ashok K. Goel, and Jeannette Yen (2011). "DANE: fostering creativity in and through biologically inspired design". In: *Design Creativity 2010*. Springer, pp. 115–122.

Voigt, Matthias and Katrin Bergener (2013). "Enhancing Creativity in Groups – Proposition of an Integrated Framework for Designing Group Creativity Support Systems". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 225–234.

Voigt, Matthias, Katrin Bergener, and Jörg Becker (2013a). "Comprehensive Support for Creativity-Intensive Processes". In: *Business & Information Systems Engineering* 5.4, pp. 227–242.

Voigt, Matthias, Ralf Plattfaut, Kevin Ortbach, Andrea Malsbender, Björn Niehaves, and Jörg Becker (2013b). "Evaluating Business Modeling Tools from a Creativity Support System Perspective-Results from a Focus Group in the Software Development Industry." In: Pacific Asia Conference on Information Systems (PACIS), p. 155.

Volkema, Roger J. and Ronald H. Gorman (1998). "The Influence of Cognitive-based Group Composition on Decision-making Process and Outcome". In: *Journal of Management Studies* 35.1, pp. 105–121.

De Vreede, Triparna, Imed Boughzala, Gert-Jan de Vreede, and Roni Reiter-Palmon (2012). "A Model and Exploratory Field Study on Team Creativity". In: Hawaii International Conference on System Sciences (HICSS). Hawaii, USA, pp. 227–236.

Walny, Jagoda, Sheelagh Carpendale, Nathalie H. Riche, Gina Venolia, and Philip Fawcett (2011). "Visual thinking in action: visualizations as used on whiteboards". In: *IEEE transactions on visualization and computer graphics* 17.12, pp. 2508–2517.

Walton, André P. (2003). "The impact of interpersonal factors on creativity". In: *International Journal of Entrepreneurial Behavior & Research* 9.4, pp. 146–162.

Wang, Clement K. and Poh-Kam Wong (2004). "Entrepreneurial interest of university students in Singapore". In: *Technovation* 24.2, pp. 163–172.

Wang, Hao-Chuan, Dan Cosley, and Susan R Fussell (2010). "Idea expander: supporting group brainstorming with conversationally triggered visual thinking stimuli". In: *Proceedings of the 2010 ACM conference on Computer supported cooperative work*. ACM, pp. 103–106.

Wang, Hao-Chuan and Yukio Ohsawa (2013). "Idea discovery: A scenario-based systematic approach for decision making in market innovation". In: *Expert Systems with Applications* 40.2, pp. 429–438.

Wang, Kai and Jeffrey V. Nickerson (2017). "A literature review on individual creativity support systems". In: *Computers in Human Behavior* 74, pp. 139–151.

Ward, Thomas B. (2004). "Cognition, creativity, and entrepreneurship". In: *Journal of Business Venturing* 19.2, pp. 173–188.

Ward, William C. (1975). "Convergent and Divergent Measurement of Creativity in Children". In: *Educational and Psychological Measurement* 35.1, pp. 87–95.

Ware, Colin (2012). *Information visualization: perception for design*. Elsevier.

Warkentin, Merrill E., Lutfus Sayeed, and Ross Hightower (1997). "Virtual Teams versus Face-to-Face Teams: An Exploratory Study of a Web-based Conference System". In: *Decision Sciences* 28.4, pp. 975–996.

Warr, Andrew and Eamonn O'Neill (2007). "Tool support for creativity using externalizations". In: *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition*. ACM, pp. 127–136.

Webber, Sheila S. and Lisa M. Donahue (2001). "Impact of highly and less job-related diversity on work group cohesion and performance: a meta-analysis". In: *Journal of Management* 27.2, pp. 141–162.

Weerawardena, Jay and Felix T. Mavondo (2011). "Capabilities, innovation and competitive advantage". In: *Industrial Marketing Management*. Capabilities, Innovation and Competitive Advantage 40.8, pp. 1220–1223.

Weick, Karl E. and Karlene H. Roberts (1993). "Collective Mind in Organizations: Heedful Interrelating on Flight Decks". In: *Administrative Science Quarterly* 38.3, pp. 357–381.

West, Joel, Ammon Salter, Wim Vanhaverbeke, and Henry W. Chesbrough (2014). "Open innovation: The next decade". In: *Research Policy*. Open Innovation: New Insights and Evidence 43.5, pp. 805–811.

Westerski, Adam (2013). *Semantic technologies in idea management systems: a model for interoperability, linking and filtering*. Adam Westerski.

Wheelan, Susan A. (2009). "Group Size, Group Development, and Group Productivity". In: *Small Group Research* 40.2, pp. 247–262.

Whiting, Bruce G. (1988). "Creativity and Entrepreneurship: How Do They Relate?" In: *The Journal of Creative Behavior* 22.3, pp. 178–183.

Wierenga, Berend and Gerrit H. van Bruggen (1998). "The Dependent Variable in Research into the Effects of Creativity Support Systems: Quality and Quantity of Ideas". In: *MIS Quarterly* 22.1, pp. 81–87.

Williams, Katherine and Charles O'Reilly (1998). "Demography and Diversity in Organizations: A Review of 40 Years of Research". In: *Research in Organizational Behavior* 20, pp. 77–140.

De Winter, Joost C. F. and Dimitra Dodou (2010). "Five-point Likert items: t test versus Mann-Whitney-Wilcoxon". In: *Practical Assessment, Research & Evaluation* 15.11, pp. 1–12.

De Wit, Frank R. C., Lindred L. Greer, and Karen A. Jehn (2012). "The paradox of intragroup conflict: A meta-analysis". In: *Journal of Applied Psychology* 97.2, pp. 360–390.

Wuchty, Stefan, Benjamin F. Jones, and Brian Uzzi (2007). "The Increasing Dominance of Teams in Production of Knowledge". In: *Science* 316.5827, pp. 1036–1039.

Xu, Bo and Dahui Li (2015). "An empirical study of the motivations for content contribution and community participation in Wikipedia". In: *Information & management* 52.3, pp. 275–286.

Yu, Lixiu L. and Jeffrey V. Nickerson (2011). *Generating Creative Ideas Through Crowds: An Experimental Study of Combination*. SSRN Scholarly Paper ID 2039547. Rochester, NY: Social Science Research Network.

Yuan, Soe-Tsyr and Yen-Chuan Chen (2008). "Semantic ideation learning for agent-based e-brainstorming". In: *IEEE Transactions on Knowledge and Data Engineering* 20.2, pp. 261–275.

Zhou, Jing (2008). "New look at creativity in the entrepreneurial process". In: *Strategic Entrepreneurship Journal* 2.1, pp. 1–5.

Ziegler, Cai-Nicolas and Jennifer Golbeck (2007). "Investigating interactions of trust and interest similarity". In: *Decision Support Systems*. Emerging Issues in Collaborative Commerce 43.2, pp. 460–475.

Zigurs, Ilze and Bonnie K. Buckland (1998). "A Theory of Task/Technology Fit and Group Support Systems Effectiveness". In: *MIS Quarterly* 22.3, pp. 313–334.

Appendix

Shared understanding of team task and goals (Johnson et al., 2007; Santos et al., 2015)	M_{EG}	SD_{EG}	M_{CG}	SD_{CG}
My team does what they are assigned to do.	1.70	0.80	3.75	0.77
My team has a shared goal for various project tasks.	1.80	0.77	3.65	0.75
My team discusses its goal and attains the agreement of teammates.	1.90	0.64	3.60	0.68
My team knows the general process involved in conducting a given task.	2.10	0.64	3.80	0.83
My team communicates with other teammates while performing team tasks.	1.95	0.76	3.95	0.76
My team uses a common vocabulary in task discussions.	1.70	0.92	2.80	0.62
My team shares information and individual team members do not keep information to themselves.	1.90	0.91	3.30	0.80
My team is committed to the team goal.	1.95	0.83	3.75	0.79
Everybody in my team strives to express his or her opinion.	2.25	0.79	4.40	0.75
My team understands their roles and responsibilities for doing various team tasks.	2.10	0.79	3.80	0.95
My team understands where they can get information for doing various team tasks.	1.75	0.91	3.85	0.75
My team informs each other about different work issues.	2.10	0.97	3.05	0.83
My team is likely to make a decision together.	1.65	0.67	4.00	0.86
My team understands how they can exchange information for doing various team tasks.	1.85	0.67	4.55	0.51
My team solves problems that occur while doing various team tasks.	1.80	0.77	3.75	1.12
There is an atmosphere of trust in my team.	2.00	0.97	2.75	0.72

My team creates a work environment that promotes productive results.	2.05	1.00	3.15	0.88
My team creates a safe environment to openly discuss any issue related to the team's success.	1.80	0.83	2.65	0.67
My team often utilizes different opinions for the sake of obtaining optimal outcomes.	2.35	1.04	3.20	0.95
My team has a positive team climate.	1.80	0.77	2.65	0.59
My team has the right experience so that a critical mass of experienced people is available on the team.	1.80	0.89	4.10	0.72
Satisfaction (Dennis et al., 1996, Santos et al., 2015)	M_{EG}	SD_{EG}	M_{CG}	SD_{CG}
How satisfied are you with the functioning of your team?	2.10	0.64	3.35	0.88
How satisfied are you with the results?	2.20	1.15	3.40	0.99
How satisfied are you with the communication among your team members?	2.25	1.12	3.35	0.93
How satisfied are you with the decisions made by your team?	1.95	0.69	4.20	0.89
How satisfied are you with the participation in your team?	1.95	1.05	3.35	0.88
How satisfied are you with your teamwork?	1.95	0.89	3.40	0.99
How satisfied are you with your team?	1.95	0.83	3.00	0.92
Perceived effectiveness (Dennis et al., 1996)	M_{EG}	SD_{EG}	M_{CG}	SD_{CG}
How effective was your team working on the problem?	2.10	0.55	3.70	0.85
How effective was your group at using all members' skills?	2.50	0.76	3.55	1.16
How effective was your team in structuring the problem or the task?	2.10	0.72	3.85	1.23
How effective was this meeting versus previous face-to-face meetings**	3.45	0.76	4.00	0.67
Structured interaction (Alrushiedat and Olfman, 2012; van der Pol et al., 2006)	M_{EG}	SD_{EG}	M_{CG}	SD_{CG}
The group discussion was structured.	2.10	0.64	4.40	0.50
The group spent little time discussing their procedure.	2.10	0.72	3.95	0.83
The discussion was focused on the assigned task.	1.55	0.76	3.35	0.67
Group members explained often what they mean.*	2.40	0.68	2.25	0.55

The discussion was task oriented and not personal or criticizing.**	1.45	0.61	1.80	0.70
*inverted				
**considered independently				

Table 11.1: Complete Survey with the Descriptive Statistics (Paper 4)